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WYE COLLEGE

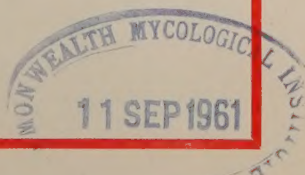
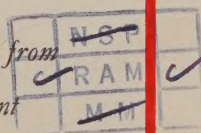
Department of Hop Research ANNUAL REPORT

1960

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INTRODUCTION

THE thirteenth annual report of the Department¹ of Hop Research gives a comprehensive review of its work. In particular, attention may be called to development of the co-operation between the Department and the National Institute of Agricultural Engineering. Mr. M. W. Shea, who was appointed by the College in August 1960, has been posted on permanent secondment to Silsoe to assist the N.I.A.E. in its hop engineering research. This appointment is to be welcomed in that it strengthens the already close partnership between the College and the Institute and increases the efficiency with which the two bodies carry out their joint research in support of the Hop Industry.

The report also contains evidence of continued and extended interdepartmental collaboration within the College in the investigation of hop problems. This is much to be encouraged since it makes for that interchange of ideas and techniques which is so beneficial to a research department tied to a single crop. It need hardly be said that this exchange is reciprocal and it gives pleasure to record that the College as a whole benefits from the interests and activities of the team of research workers which constitutes its oldest research department.

Mr. J. B. Smithson was awarded the Guinness Postgraduate Studentship in August 1960, for research on hop genetics. Thanks are again due to Messrs. Arthur Guinness Son & Co. (Park Royal) Ltd. for their generosity in providing the funds for this studentship.

Acknowledgement is made of continued support received from the Agricultural Research Council, the Hops Marketing Board and the Institute of Brewing. No less appreciated is the keen interest in hop research which is shown by these bodies and their members for which gratitude is gladly expressed.

Once again the College gratefully acknowledges the ready co-operation it receives in its hop research work from its colleagues at East Malling Research Station and in the National Agricultural Advisory Service.

DUNSTAN SKILBECK.

June, 1961

REVIEW OF RESEARCH

H. S. DARLING

INVESTIGATIONS have continued on a wide range of hop problems. Plant breeding research is discussed in a review article on page 9. Breeding for tolerance to progressive *Verticillium* wilt receives a deservedly high priority and it gives satisfaction to note that the three English-type wilt-tolerant seedlings from the Wye/East Malling Joint Scheme have successfully completed their first year in farm trials on wilt-infected farms in the Weald of Kent. These experimental varieties have maintained under commercial conditions the high levels of wilt tolerance previously recorded in wilt tests at East Malling Research Station. The crop from these farm trials in 1961 is to be used for large scale brewing trials.

The results of wilt tests on triploid seedlings from tetraploid commercial varieties pollinated by diploid tolerant males indicate that such crosses are unlikely to give progeny with adequate wilt tolerance for commercial success. This is a disappointment in view of the hopes originally placed in this particular polyploid approach to the wilt problem. This disappointment is mitigated by two factors; first, the polyploid breeding programme has been supported throughout by a conventional diploid programme. Second, recent research at Wye has shown that some tetraploid plants regularly produce both male and female flowers with viable pollen as well as normal cones. Such monoecious plants can first be selected for wilt tolerance and brewing quality and then used as male parents to pollinate diploid commercial varieties. By this means it is hoped to increase greatly the probability of producing triploid seedlings that are both wilt-tolerant and commercially acceptable.

Triploid varieties are considered to have advantages under English conditions over their diploid counterparts because of their lower seed content and tougher cones. The first of these qualities may be expected to commend triploid hops to English lager brewers and may eventually open doors for an export market. The second is of obvious importance in machine picking. It is not yet known how triploids compare with normal diploid varieties in respect of yield and ease of management under conditions of commercial practice. It is hoped to get information on these

important points through farm trials now being established with a triploid seedling of Bullion.

This triploid Bullion seedling is wilt-sensitive and so will be of interest to growers in areas not yet affected by progressive wilt. Of equal interest to such growers is current work at Wye on the selection of improved clones of Goldings which is discussed in a progress report on page 30. Similar selection work on Fuggle clones is also being carried out at Wye and is discussed briefly in a review article on page 13. Mention is also made of a new series of international variety trials in which German, English and Danish varieties will be grown on a number of sites in the main hop growing areas of Europe. The first plots of this series have been established at Wye and on the Continent. These trials have been arranged by the Hop Liaison Committee on which the European Brewery Convention and the Scientific Commission of the European Hops Cultivation Committee are jointly represented.

Chemical research on hops is discussed on page 16. The Department has benefited greatly through the installation of gas chromatography equipment which is being used in preliminary studies on hop quality. New seedlings are being examined for cohumulone and oil content, and with increasing experience in this field of work, the plant breeder may expect more precise guidance in his selection of new varieties. Trials with gibberellic acid on Bullion were carried out in collaboration with the Brewing Industry Research Foundation. These have failed to confirm results obtained in Australia which indicated enhanced yields of hops with very low content of alpha acids.

Research on downy mildew disease is discussed on page 23. Work on the overwintering of the disease has produced further evidence that it perennates as a vegetative mycelium in the rootstock; each spring the primary basal spikes develop from buds infected by this mycelium. Hill dusting of clean plants with Bordeaux powder during the growing season continues to give an encouraging degree of protection from rootstock attack by the fungus. This approach to the problem is being extended.

Further trials with streptomycin against downy mildew have been carried out; griseofulvin oxime has also been examined. Both chemicals were applied to the hills early in the growing season. Griseofulvin had no effect. The streptomycin-treated plants produced as many primary basal spikes as the controls, but these spikes gave fewer spores than untreated spikes, and the infective capacity of the spores from treated spikes was greatly reduced. As

a result, the streptomycin-treated plants had many fewer secondary infections than the controls. These results, which confirm data already obtained in the U.S.A., are more promising than those recorded in trials at Wye in 1958.

Investigations on the physiology of the hop crop are briefly reviewed on page 26. Research continues on the storage of carbohydrate reserves in pot plants and in plants in the field. It has been found that with young plants the normal stripping of main stem leaves and cutting the bine at harvesting both reduce the size of the storage organ. The effects of such treatments on yield in the subsequent season are being examined. Changes in the carbohydrate reserves during dormancy are discussed in a paper on page 48 in which it is also shown that downy mildew infection of the rootstock results in the rapid loss of starches and sugars. This paper emphasizes the importance of the vernalizing effect on the rootstock of cold weather during winter; low temperatures break dormancy and make possible the characteristic rapid bine growth which occurs in the spring.

Research on mist propagation has been continued and extended. Mist-propagated cuttings were planted out in nursery rows at different times during the growing season to determine the size of the storage organ formed. The resulting setts have been planted out in a replicated trial with the object of measuring yield differences in the year of establishment. Work on hop propagation has also been carried out in collaboration with the Department of Horticulture, Wye College, and the results are set out in a paper on page 37. The importance of light in supplying photosynthetic energy during the rooting period is emphasized. The mist propagation technique makes it possible to maintain full turgor in the leaves in the absence of shade; under the conditions of the experiments described it was found that the more light the cuttings received the more satisfactory was their growth and rate of rooting.

Research on hop engineering problems has made encouraging progress and is reviewed on page 28. Other papers dealing with this work appear on pages 72 and 78. Considerable attention is being given to factors affecting the life and performance of hop wirework systems. Data on tensions in established wirework are accumulating through the use of recording dynamometers incorporated in the anchor wires of the height of wirework and spacing trial at Wye. The results to date suggest that the effect of storms increases with increase in height but to a lesser extent than might be expected. Corrosion tests have confirmed the experience of many growers that

spraying with the traditional Bordeaux mixture can cause serious damage to galvanized wire. A study on the strength of anchor wire showed that such wire failed at a load of approximately two tons. The normal method of fixing the wire to the eye of the anchor rod failed at less than half this load.

A preliminary assessment of hop picking machine efficiency is described on page 72. When worked over the full range of capacity for which it was designed, the College machine was remarkably consistent in its performance and delivered more than 90% of the cone material present on the bines. The accuracy of these tests is indicated by the fact that more than 95% of all the dry matter (including stems, leaves and string) fed into the machine was accounted for in each test run. It is hoped to continue these studies in 1961.

The height of wirework and spacing trial was continued and the results for 1960 are discussed on page 59. As in 1959 this trial was used for a comparison of hand and machine picking. Once again results were encouraging. The wet summer of 1960 gave more vigorous growth than in 1959 and yields were higher. Under these conditions the machine gave consistently lower yields of clean dry hops than were obtained by hand picking. Nevertheless, treatment effects were clearly and accurately demonstrated and random errors were less with machine than with hand picking.

This trial was once again used for studies on the number and distribution of mature cones on the bines with different treatments. Wider spacing markedly increased the number of cones per bine but did not give higher yields per acre than the closer spacings. Lower wirework was associated with the development of a tangled head even at the widest spacing. Higher wirework gave less head formation and more even distribution of cones along the bines. This was associated with an apparent improvement in picking machine performance when growth was more vigorous.

Research on field management aspects of machine picking and on methods of disposal of wilt-infected waste material from picking machines has made good progress. Results will be published in due course. More than 90% of the 417 growers using machines have contributed information which is now being analysed together with data from an intensive survey in September 1960, of a representative sample of 20 farms. The burning of infected waste (which is the safest method of disposal) proved difficult if not impossible under farm conditions in the wet weather of 1960. Composting waste material can be relied on to give lethal temperatures for wilt in

the centre of suitably constructed heaps. Careful turning of the compost is subsequently necessary to ensure that the peripheral material of the original heap will also heat to lethal temperatures.

Grateful acknowledgement is made to the Ministry of Agriculture, Fisheries and Food for permission to publish Appendices II and III giving brief accounts of the 1960 hop season in the West Midlands and the South East respectively. These appendices which are written by the Ministry's Hops Advisers for the respective regions, emphasize the effect of adverse weather conditions during the summer and autumn. They also emphasize the continuing increases in machine picking and in the incidence of progressive wilt. As pointed out in a recent article by a leading hop merchant* these last two factors at present dominate the English hop industry and are bringing about profound and far-reaching changes.

The College has continued to maintain close contact with European hop research workers. The Scientific Commission of the European Hops Cultivation Committee met in full session in Czechoslovakia in July 1960. Wye was represented on this occasion and papers were read by departmental staff. The opportunity was taken to visit the Czech hop research centre at Zatec. A one-day meeting of the Scientific Commission was held in Strasbourg in February 1961 and once again Wye workers took part in the proceedings. This last meeting was preceded by a meeting of the Liaison Committee already referred to, on which the College was also represented.

Care has been taken to keep the Wye research team in close contact with the Hop Industry through the appropriate committees and activities of the Hops Marketing Board, the National Agricultural Advisory Service and the Institute of Brewing. Personal links between the Industry and departmental staff have been increased. It is regretted that visitors to the College hop gardens must still be discouraged owing to *Verticillium* wilt.

Collaboration has continued with the National Institute of Agricultural Engineering, with East Malling Research Station and with the Brewing Industry Research Foundation. Thanks are due to the N.A.A.S. for co-operation and help in the maintenance of quarantine gardens and outstations in the Cambridge and Stratford-on-Avon areas. The opportunity is taken to thank Dr. H. H. Glass-

* "The future of the Fuggle" by F. N. Richardson: *The Brewing Trade Review*, 1960, p. 682.

cock, Regional Plant Pathologist, N.A.A.S., for help in connection with *Verticillium* wilt and research on downy mildew.

Thanks are also due to Guinness Hop Farms Ltd. and to other growers for co-operation enjoyed in various extensions of departmental research. Grateful acknowledgement is also made of help received from friends in the Borough.

REVIEW OF THE 1960 HOP SEASON AT WYE COLLEGE

H. S. DARLING

THE summer drought of 1959 was followed by a wet winter which brought the soil in all hop gardens back to field capacity. The 1960 growing season, after a warm dry start, was cool and wet with low figures for sunshine. Meteorological data for Wye for 1960 are set out below, mean values for the 26-year period 1935-60 being given for comparison.

	Rainfall Inches per month		Sunshine Hours per day		Mean Temperature °F.	
	1960	1935-60	1960	1935-60	1960	1935-60
January ..	3.23	2.98	1.25	1.74	38.3	38.0
February ..	2.01	2.38	3.23	2.51	39.5	38.6
March ..	1.71	1.83	2.93	4.11	43.4	43.0
April ..	0.84	1.56	5.21	5.83	47.8	47.6
May ..	1.54	1.90	5.96	6.96	54.5	53.0
June ..	1.47	1.79	7.66	7.46	58.8	58.7
July ..	2.96	2.25	5.21	6.76	58.9	61.8
August ..	4.45	2.67	5.72	6.28	58.8	61.7
September ..	2.81	2.35	4.54	5.10	55.8	58.1
October ..	7.63	3.36	2.76	3.69	51.4	51.1
November ..	5.87	3.67	2.25	2.13	45.2	44.6
December ..	4.66	3.07	1.67	1.56	40.8	40.4
Total ..	39.18	29.81				

Plant development was good and bine growth was heavy. Average yields of up to 25 cwt. dried hops per acre were picked from mature stands of commercial varieties. The wet conditions under which the crop ripened appeared to favour Fuggle and Northern Brewer; the yield of Goldings was relatively disappointing.

Aphis attack which began in mid-May was never severe and was easily controlled by systemic insecticides. No damage from red spider was observed. Downy mildew was active throughout the growing season, control being made difficult by wet weather which

hindered routine spraying operations. Copper dusts were used extensively during August and a clean crop was eventually harvested. Mould was satisfactorily controlled by routine sulphur dusting supplemented by a high volume karathane spray at the end of May.

The fungus from the single hill found to be infected with *Verticillium albo-atrum* in 1959 proved on test to be a mild case of fluctuating wilt. No further cases of *V. albo-atrum* in hops were recorded on the College farm.

The crop ripened late. Picking began on 5th September and ended on 6th October, operations being made difficult by wet weather. While the crop did not weigh well on drying, the 1960 ratio of 118 green bushels per dried cwt. was an improvement on the 1959 value of 123. Approximately 42,500 green bushels of hops were harvested, giving a record yield for the College farm of 359 cwt. as weighed at the oast after drying. Details of yields for 1958-60 are given below:

				1960	1959	1958
				cwt.	cwt.	cwt.
Goldings	..	..	..	55.0	52.5	67.0
Fuggle N	..	..	..	53.5	25.0	4.5
Northern Brewer	..	..	..	109.5	37.0	7.0
Bullion	..	..	..	80.5	53.5	10.5
W.G.V.	..	..	..	8.5	—	—
Plant Breeding Hops	..		..	52.0	52.5	55.5
				359.0	220.5	144.5

Of the 1960 total, about 175 cwt. were picked by machine compared with 55 cwt. in 1959. The large yield in 1960 was due in part to good growing conditions and in part to new plant in Withersdane hop garden coming into full bearing.

In the winter of 1960-61 the small isolation garden used for research on downy mildew disease became involved in a College land transaction and was grubbed. It is being replaced on a suitable site on the eastern edge of the farm, well away from all other hop gardens. The wirework of Silks garden was replaced during the 1960-61 winter and was raised from 14½ to 16 feet.

PLANT BREEDING SECTION

REVIEW OF THE YEAR'S WORK

R. A. NEVE and R. F. FARRAR

IN recent years a large part of the hop breeding programme has been devoted to attempts to develop wilt tolerant triploid varieties. The early work with triploid seedlings confirmed that they showed some of the advantages that were expected of them, notably a low seed content and closer resemblance to the female parent from which they were bred. There was a risk that the preponderance of the female characters would include wilt susceptibility, but from the behaviour of diploid families it seemed likely that wilt tolerance was sufficiently dominant to be transmitted successfully to triploid seedlings. Wilt tests on triploid seedlings carried out at East Malling in 1959 and 1960 have indicated, however, that an inadequate level of tolerance is found in triploid seedlings raised from susceptible tetraploid and tolerant diploid parents.

If the breeding of tolerant triploids is to continue, a new approach will be necessary, and fortunately some of the research work recently completed has suggested an alternative method.

Although monoecious plants (i.e. plants with both male and female flowers) occur quite frequently amongst diploid seedlings, none of these has yet been found to produce good pollen. It has now been found that tetraploid seedlings which have one Y and three X chromosomes, are not only monoecious but produce viable pollen. Since such plants produce normal cones which can be examined for aroma, resin and oil content, they can be selected for quality as well as for wilt tolerance, and pollen from their male flowers can then be used to fertilize normal female plants.

By this technique it is possible to assess directly the cone quality of both parents. When ordinary male plants are used as pollen parents the quality characters which they will transmit to their seedlings cannot be foreseen, and the chances of selecting good males are very small.

The success of the new technique will depend upon first producing tetraploid monoecious plants having the necessary combination of cone quality and wilt tolerance, and with this

object three crosses were made in 1960 between tetraploid Whitbread's Golding Variety and tetraploid male or monoecious plants.

The speed with which this new technique can be exploited will be limited by the time required to produce the 30 setts that are necessary before a variety can receive an adequate wilt test. It is encouraging that East Malling Research Station have started investigating the possibility of developing a quicker testing method using pot plants.

FARM TRIALS

The three farm trials of the three wilt tolerant varieties to be tested as possible replacements for Fuggles were successfully established, but the single trial of three varieties of American type suffered damage from the use of soil applied dimefox to which these varieties are susceptible. Propagation of the triploid seedling of Bullion (WFT 2) was carried out by a grower in the West Midlands and the material used to start the planting of two farm trials in that area.

It is interesting to note that WFT 2 is not, as stated last year, the first triploid seedling to be released for trial. The variety AGG 8, raised by Professor Salmon in 1932, is grown by a brewer-grower who has commented on its low seed content. This variety has now been examined and proved to be a triploid. Such triploid females are known to arise spontaneously only rarely and the fact that this one was selected from amongst thousands of other seedlings suggests that some of its good features may be a direct result of its triploid nature.

BREEDING PROGRAMME

The diploid breeding programmes for both wilt tolerance and downy mildew resistance are designed to eliminate the undesirable characters associated with the plants which have been the original sources of resistance. In the case of wilt, the tolerant males used so far have transmitted an American aroma to many of their seedlings, while the downy mildew resistant plants received from Germany lack vigour and have low resin contents. In each case it was possible, in 1960, to breed from plants that were a generation further removed from the original sources, with correspondingly greater chances of success.

In the downy mildew programme, crosses were made between male and female seedlings of the original German parents, which had been selected for both resistance and general vigour.

The crosses made in the wilt tolerance programme were different from any made before. Earlier families have been raised from wilt susceptible females (such as Fuggles or Goldings) pollinated by tolerant males that were first generation seedlings of wild American hops. On the results of 3-plant wilt tests at East Malling in 1959, four male seedlings from one of these earlier families (Eastwell Golding $\times$ OB79) were selected because they showed no wilt symptoms. A 3-plant test does not provide conclusive evidence of the level of tolerance, but since these males were a generation further removed from the wild American parent than those used before, it was decided to breed from them without waiting a further two years for the results of 30-plant tests. They were, therefore, used to pollinate Whitbread's Golding Variety (1147) which is the most successful of the wilt tolerant varieties so far available, while the first generation male (OB79) was also used to provide a comparison.

RESEARCH PROGRAMME

The probable value of tetraploid monoecious plants to the breeding programme has already been mentioned. A further possibility of overcoming the difficulty of having to work with males which transmit unknown quality characters arises from the report by Weston (1960) that male flowers can be induced on female varieties by chemical treatment. If treated plants produced viable pollen it would then be possible to cross together female varieties of known quality and, incidentally, raise families consisting entirely of female plants. Weston suggested that the effect of the chemical used—alpha(2-chlorophenylthio)propionic acid (or 2 PSP)—might be due to its weak growth promoting properties. Accordingly, Fuggle plants were treated in 1960 with NAA, IAA and 2:4-D as well as with 2 PSP. Of these only 2 PSP induced male flower development and, as in Weston's experiments, no viable pollen was produced. The treated plants were, in fact, very similar to naturally occurring diploid monoecious plants. Because of its possible practical importance this work is to be extended and the chemist has synthesized a further ten compounds, related to 2 PSP, for use in 1961.

The fact that some new varieties are susceptible to damage by dimefox has been mentioned in earlier reports and during 1960

the practicability of assessing susceptibility on pot plants was investigated.

Mist propagated material was grown in five-inch pots, only one bine per pot being allowed to grow. When the bines were about three feet high the potted plants were treated with dimefox. Various strengths were used, and it was found that a one-twelfth commercial dose (two fluid ounces at one-sixth strength) gave symptoms approximating to those observed on mature hills treated with a normal commercial dose in the field.

Using uniform batches of potted material in this way should prove far more convenient than testing varieties in the field, and it is intended that any new variety showing promise of commercial acceptance will be checked, in this manner, before being subjected to commercial applications of dimefox.

REFERENCE

WESTON, E. W. (1960). Changes in sex in the hop caused by plant growth substances. *Nature (Lond.)*, 188, 81-2.

FIELD EXPERIMENTATION SECTION

REVIEW OF THE YEAR'S WORK

F. C. THOMPSON and F. H. BEARD

GENERAL

The section has continued to assist the Head of the Department in the general management of the commercially grown hops at Wye. An account of the growth of the crop from this aspect, is given on page 7.

Mr. Thompson continued to serve as a member of the Hops Working Party of the N.A.A.S. and of the Scientific Commission of the European Hops Culture Committee. At the conference of the latter, held in Czechoslovakia in July, 1960, he presented a paper on leaf analysis in relation to hop nutrition. He also represented the Scientific Commission at the meeting of the European Brewery Convention Hops Liaison Committee, held in Strasbourg in February, 1961.

HEIGHT OF WIREWORK AND SPACING TRIAL

Crop yield and other data were recorded for the second year and the trial was again used to investigate the picking of experimental plots by machine. A report on this experiment is given on page 59.

TRIAL OF GOLDING CLONES

Data were recorded for the third year and a progress report on the results to date is given on page 30. The results show consistent differences in seasonal order of burr and cone development.

TRIAL OF FUGGLE CLONES

This trial was harvested in plots for the first time in 1960.

Of the 11 clones under test, three are very early in season and were picked on 31st August, the others being harvested on 8th September. The mean dry matter and total soft resins content of the early clones were appreciably higher than the corresponding values for the eight later clones (dry matter 19.35 and 17.20

per cent., T.S.R. 11.44 and 10.80 per cent., respectively). The mean yield of the early clones, however, was only 14.8 cwt. per acre compared with 21.6 cwt. per acre from the later clones.

Low cropping capacity is a feature of very early hop varieties and appears to be related to early development of burr. Vegetative growth then ceases and the plant does not produce enough fruiting laterals to bear a heavy crop. In 1961, the cultural treatments given to the early clones will aim at encouraging earlier vegetative growth.

EUROPEAN BREWERY CONVENTION: HOPS LIAISON COMMITTEE VARIETY TRIALS

In this trial, to which brief reference was made in the previous annual report, the growth and cropping of selected Danish, English and German varieties is being investigated. The trial was planted in Withersdane Garden in Spring, 1960, and a satisfactory take was obtained with all varieties except the Danish S978, where seven hills failed to establish; subsequent observations suggest that this variety may be prone to downy mildew infection of the rootstock. Growth of established hills in 1960 was generally good with all varieties except the German Spalt, which had to be planted with very small pot roots; all other varieties produced a useful crop of cones, which were sampled for resin analysis. The Danish S1478 gave the best analysis, confirming its reputation as a high resin hop.

FIELD MANURIAL TRIALS

Of the three 3³ NPK trials established at Bodiam, Sussex, and Teynham, Kent, that in Shinmore Garden at Bodiam was abandoned in 1960, owing to severe downy mildew infection of the rootstocks. In the remaining two trials, apart from an indication of response to high potash, at Teynham, there was no evidence that the higher levels of NPK tested had enhanced crop yield.

The large experimental errors which are common in outside field trials make it difficult to obtain valid results. Shortage of land has previously prevented the establishment of manurial trials at Wye, but in 1959 a 3³ NPK trial was laid down in Withersdane Garden and this should enable closer control to be kept on experimental uniformity. The variety under test is Whitbread's Golding Variety (1147), a wilt-tolerant hop now widely planted. Records of crop yield were taken for the first time in 1960, when there was an

indication of a response to high potash, but no evidence of response to increasing levels of nitrogen and phosphate.

Soil and leaf samples for mineral nutrient analysis were collected from all the trial plots including leaf samples from the hop manurial trial at the Rosemaund Experimental Farm. Data from soil analysis have been found to be useful for manurial recommendations, but leaf analysis, while of importance in diagnosing mineral deficiencies, has not so far proved to be a sensitive indicator of yield response to differential manuring on soils of average to high fertility. Further work is being carried out on the effect of leaf position and time of sampling, in an attempt to improve the sensitivity of leaf analysis.

Samples of hop cones, for resin analysis, were also taken from the trials, including the Rosemaund trial. Over a period of years, the effect of manuring on resin content has been small, but there has been a consistent trend for high nitrogen to depress, and high potash to increase, resins.

WOUND SEALING OBSERVATION TRIAL

When hop bines are cut for machine picking it has been said that there may be some loss of nutrient material from the rootstock through bleeding, which, in turn, may reduce yield in the following year. In 1959 the cut bines in certain guard rows in the height of wirework trial, were treated with a proprietary wound sealing compound and in 1960 the yields from these rows were recorded, together with the yields from comparable untreated guard rows. No difference in yield was found.

STATISTICAL WORK

The statistical analysis of the results of departmental field experiments, and of resin analysis and leaf analysis data from the Rosemaund hop manurial trial, has been carried out. Assistance has been given with the design of new field experiments in other sections.

CHEMISTRY SECTION

REVIEW OF THE YEAR'S WORK

J. B. ROBERTS

GAS CHROMATOGRAPHY. DETERMINATION OF THE COHUMULONE CONTENT OF HOPS

A micro method for this determination has been developed. The method is based on the pyrolysis technique of Rigby *et al.* (1960). Approximately 1 mg. of alpha acid lead salt is decomposed by heating to approximately 800° C. for a few seconds in the gas chromatography apparatus. The iso-butyric acid and 2-methyl butyric and iso-valeric acids produced from cohumulone and from adhumulone and humulone are separated in the apparatus and their relative proportions determined. Single analyses can be carried out in approximately 30 minutes.

Figures for some varieties in the 1960 crop at Wye are given in the table:

<i>Variety</i>	<i>Cohumulone % of alpha acid</i>
Fuggle	26, 27
Northern Brewer	28, 28
Eastwell Golding	28, 28
Bullion	49, 51
<i>Humulus lupulus</i> var. <i>neomexicanus</i> ..	67, 67

A fuller account of this work is at present in press.

HOP OIL

With a view to using the gas chromatography apparatus as a test for desirable and undesirable aroma in seedling varieties, oils were isolated by steam distillation from samples of 45 varieties supplied by the Plant Breeding Section. Samples of the same varieties were sent for assessment by the merchants. A comparison of the results of gas chromatography of the oils and the merchants' assessments, tends to confirm the results of Howard and Slater (1957) that "American" aroma is connected with high myrcene content. However, the general question of desirable and undesirable

aroma is more complex. The hydrocarbon fractions of hop varieties are difficult to distinguish from one another, whereas the oxygenated fractions have more characteristic aromas.

Much more basic information about the individual constituents of the oil, and their utilization in the brewing process, is required.

GROWTH SUBSTANCES. THE EFFECT OF GIBBERELIC ACID ON YIELD AND RESIN CONTENT OF HOPS

During the year an experiment was carried out in collaboration with the Brewing Industry Research Foundation under English conditions to check the results of the Australian workers Nash and Mullaney (1960). Plots of 25 hills of Bullion were sprayed in midseason with a solution of 12.0 p.p.m. of gibberellic acid as the potassium salt. Samples were taken at 14-day intervals, starting 14 days after the final spraying, until 29th September, 1960, when the plots were harvested. Resin and oil analyses were carried out, and plot yields determined. The table below shows the results obtained on the final samples.

	Spraying date	Yield lb. green hops/bine	% Dry Weight		
			alpha acids	T.S.R.	Oil %
A	14.6.60	2.07	9.5	17.7	1.7
B	14.6 and 23.6.60	1.09	9.3	17.7	1.8
C	23.6.60	2.24	8.4	16.4	2.0
D*	19.7.60	2.59	6.5	13.7	1.6
Control	—	3.25	6.3	13.6	1.5

* Equivalent to Nash and Mullaney's Treatment.

These results are in marked contrast to those of Nash and Mullaney. A short note incorporating some of the results is in press.

SEX REVERSAL IN FEMALE HOPS

A series of eleven compounds related to alpha(2-chlorophenylthio) propionic acid (Weston, 1960) were synthesized for use in the Plant Breeding Section's programme of research.

ROUTINE ANALYSES

During the year approximately 800 resin analyses have been carried out in support of research in the Department and elsewhere.

Analyses of leaf and soil samples for inorganic constituents in support of manurial trials, and carbohydrate analyses of root samples in support of physiological studies have continued.

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ENTOMOLOGY SECTION

REVIEW OF THE YEAR'S WORK

H. S. DARLING

SYSTEMIC INSECTICIDES AND CONTROL OF THE HOP APHIS

The replicated insecticide trial on the control of the hop aphid, *Phorodon humuli* Schr., carried out in 1958 and 1959 (Darling and Beard, 1959; Darling, 1960) was continued, the treatments being:

- (1) Derris applied as a high volume spray.
- (2) Demeton methyl applied as a soil drench to each hill at 0.25 gm. in 120 ml. water per application.
- (3) Dimefox applied as a soil drench at the same rate as in (2) above.

In the winter of 1959-60 the hills used in this trial were grubbed and replanted with new bedded setts of the same variety, i.e. Petham Golding, the layout being slightly modified in the process. These new setts had received during the previous season the same insecticide as the experimental treatment applied to the plots in which they were planted. The object of this was to reduce the possibility of carry-over effects in the rootstocks.

The derris sprays were applied seven times from 2nd June to 4th August. Demeton methyl was applied three times on 30th May, 24th June and 25th July. Dimefox was applied twice on 30th May and 29th June. At each application of the derris spray, the other treatments were similarly sprayed with water only.

Attack by *P. humuli* was light and intermittent during the summer of 1960. Winged migrants first appeared in the crop in mid-May and populations increased slowly thereafter until by early June 100 per cent. of the leaves were infested with later stage nymphs and wingless adults. Both systemic insecticides maintained good control throughout the summer with observed maxima of 5 per cent. of leaves infested. The derris treatment gave inefficient control with an average of 56 per cent. of leaves infested during June and July. In August all treatments appeared to be aphid-free.

Examination of ripe cones on 21st September gave the following results:

Derris	46 %	of cones infested		
Demeton methyl	1 %	"	"	"
Dimefox	0 %	"	"	"

With such young plants, no selection was made in respect of the type of bine growth trained up the strings in May. All shoots that grew were trained and on 6th August a count was made of all strings with bines that had reached the top wire. Results were as follows:

Derris	145	(maximum possible 240)		
Demeton methyl	170	"	"	"
Dimefox	186	"	"	"

There was considerable plot to plot variability and none of the differences observed was statistically significant.

The experiment was harvested by hand on 21st September. Mean yields of dry hops (10 per cent. moisture content) were as follows:

Derris	9.28	cwt. per acre		
Demeton methyl	11.88	"	"	"
Dimefox	13.64	"	"	"

Least significant difference ($P = 0.05$): 2.74.

These data agree with those recorded in 1958 and 1959.

Estimates were made of the number of bushels of green hops required to give 1 cwt. of dried hops. The results obtained are summarized below:

Derris	94	green bushels per cwt.		
Demeton methyl	107	"	"	"
Dimefox	101	"	"	"

Least significant difference ($P = 0.05$): 3.8.

The derris treatment required significantly less bushels of green hops per dried cwt. than did the two systemic insecticides. This finding confirms the results of earlier surveys of data from hop farms (Darling, 1958).

Samples of dried hops from the different treatments were

analysed for resin contents and the following average values obtained:

	<i>Alpha acids</i>	<i>Beta fraction</i>	<i>Total Soft Resins</i>
	%	%	%
Derris	4.8	6.1	10.9
Demeton methyl	4.3	5.6	9.9
Dimefox	4.9	6.1	11.0

These resin data are at variance with those obtained in 1959 when the demeton methyl and dimefox treatments had the highest and lowest values respectively.

It should be emphasized that all the results given above must be interpreted with caution in view of the youth of the plants.

OBSERVATION TRIALS WITH NEW SYSTEMIC INSECTICIDES

Small-scale observation trials were carried out with phosphamidon (2-chloro-2-diethylcarbamoyl-1-methylvinyl dimethyl phosphate) applied as a foliar spray and a soil-applied German compound, S.276 (0,0-diethyl-S-2-(ethylthio) ethyl: commercially known as "Disyston"). Neither of these insecticides caused any phytotoxic symptoms in Goldings, Fuggle N, Northern Brewer or Bullion when applied at dosages above those normally recommended.

Phosphamidon when sprayed at high volume at a concentration of 0.02 per cent. active ingredient, gave good commercial control of *P. humuli* for up to three weeks. Similarly applied at a concentration of 0.04 per cent., phosphamidon gave good commercial control for four weeks.

The compound S.276 was applied via the soil as a granular formulation containing 5 per cent. of the active ingredient. It was not applied to the crowns of the hills, but was lightly forked into the surface soil over a circular area 1 metre in diameter around each hill. Treatments of 10, 20 and 30 gm. of the formulation per hill were applied three times during the season in early May, early June and early July. None of the treatments became effective until late June; uptake of the insecticide appeared to coincide with the obvious development of the fibrous superficial root system. Thereafter the two higher dosage rates gave good commercial control. The lowest rate gave adequate control under the conditions of light attack in 1960, but might not have given sufficient protection in seasons of heavier infestation.

PHYTOTOXICITY OF DIMEFOX

Research on the development of a technique for assessing the relative toxicity of dimefox to hop varieties was carried out by the plant breeders and is reported on page 12.

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PATHOLOGY SECTION

REVIEW OF THE YEAR'S WORK

J. R. COLEY-SMITH and F. H. BEARD

HILL DUSTING OBSERVATION TRIAL, 4TH YEAR

This long-term hill dusting experiment has continued to give encouraging results. The amount of systemic rootstock infection was almost the same as in 1959, but basal spike numbers were lower probably as a result of the long dry spring in which there were few secondary infections.

A new clonal Eastwell Golding dusting trial was started in 1960. Very little infection was recorded on any of the plots. Applications of Bordeaux powder to the hills during the growing season did not result in a reduction of yield and had no effect on the alpha acid and total soft resin content of the cones.

No basal spikes were recorded in a hill dusting trial commenced in 1960 on a commercial grower's farm. This trial is being carried out in conjunction with the National Agricultural Advisory Service.

STREPTOMYCIN AND GRISEOFULVIN TRIAL

A previous trial of agricultural grade streptomycin sulphate gave discouraging results (Coley-Smith and Beard, 1959). In view of further claims for this chemical by American workers, a second small-scale trial, which also included griseofulvin oxime, was carried out on the control of downy mildew in old hills of Eastwell Golding. The materials were used as sprays at 1,000 p.p.m. Two applications of the sprays were applied to run off, the first when the shoots were 4-6 in. in length and the second three weeks later when the longest shoots were about 3 ft. Apart from a small number of marked spikes, normal spiking operations were carried out. Griseofulvin oxime had no effect. While the number of primary basal spikes was unaffected secondary basal spikes on the streptomycin treated plots were only one-tenth as numerous as on the control unsprayed plots. Streptomycin brought about a partial recovery of spiked shoots. The streptomycin treated spikes produced fewer sporangia than untreated spikes when incubated in a humid

atmosphere. Sporangia from treated spikes were also reduced in infectivity. The lower numbers of secondary basal spikes on streptomycin treated plots were presumably a result of the above effects. Despite the large reductions in secondary infections it is not considered that the use of streptomycin could replace traditional spiking operations. These results will be published, in detail, elsewhere.

DOWNY MILDEW RESISTANCE TESTS

The value of a seedling test for selecting downy mildew resistant hops has been investigated further. Plants subjected to a seedling test have been compared for their degree of resistance by means of the detached leaf technique (Coley-Smith, 1960) with unscreened plants obtained from the same batch of seed. The screened series contained a higher proportion of resistant plants than the unscreened batch. Routine testing of seedlings produced by the Plant Breeding Section is now under way.

Plants screened for resistance by detached leaf and shoot tests were planted in an unsprayed garden. Some of these made sufficient growth for the amount of infection on the cones to be assessed at the end of the season. Of these varieties seven of nine recorded as more resistant than Fuggle N by the shoot test had less cone infection than Fuggle and of four varieties recorded as less resistant than Fuggle all had more cone infection.

OVERWINTERING OF *Pseudoperonospora humuli*

Work on this subject has been largely completed and has confirmed the results discussed in last year's report. This work will shortly be published in detail.

MECHANISMS OF INFECTION OF HOP ROOTSTOCKS BY *Pseudoperonospora humuli*

Research has commenced on discovering how healthy hop rootstocks become systemically infected by the downy mildew fungus. It has been confirmed with pot plants that from spiked basal shoots the fungus could grow in the host tissue down below the soil surface and into the one-year-old portion of the rootstock. It was also confirmed that stem infection, without spike formation, could result in rootstock infection. This may prove to be of great practical importance, since such infected shoots would not be removed during spiking operations.

This research is being augmented by penetration studies. Stomatal penetrations of leaves and stems have been observed on numerous occasions, but direct penetrations of the cuticle have not been seen.

WINTER SUPPLY OF INOCULUM

This has been developed further. Dormant rootstocks are retained in a refrigerator at just above freezing point and are potted up when required. Rootstocks have been kept for over a year in this condition. After adequate development the plants are atomized with zoospore suspensions and incubated in a growth room maintained at 17-18° C. Sub-culturing is done at weekly intervals. This method, whilst requiring little time and effort, ensures large crops of sporangia.

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CROP PHYSIOLOGY SECTION

REVIEW OF THE YEAR'S WORK

I. H. WILLIAMS

FOOD STORAGE AND CULTURAL TREATMENT

Fundamental studies upon young plants of the variety Fuggle N grown in the open in pots were repeated. These confirmed earlier findings, that food reserves accumulated in the latter part of the growing season are utilized for shoot development in the following spring and early summer. In 1960 two cultural treatments were imposed: a group of plants were stripped of their lower leaves in May and early June, following standard commercial practice and a further group were cut back in September at harvest time as for machine picking. Under both these treatments, plants developed significantly smaller rootstocks, with a smaller reserve of food materials than the control plants at the end of their first year. A number of rootstocks from each treatment has been planted in the field so that the effect upon yield in the subsequent year can be assessed. Experiments carried out elsewhere have shown that stripping and cutting treatments appear to have little effect upon the yield of mature hop plants in the following year, grown under good conditions. It seems possible that stripping and cutting, both of which interfere with the photosynthetic processes of the plant and hence its capacity to accumulate reserves in the autumn may retard the development of full cropping capacity in newly-planted hops. These experiments will be described more fully when completed.

PROPAGATION

Soft-wood cuttings of the variety Fuggle N were propagated in a glasshouse using the "mist" technique at two-week intervals throughout the growing season. When well rooted, cuttings were planted in the open. At the end of the growing season the plants were carefully excavated and the green weights of the rootstocks compared with normal bedded setts grown from strap cuts planted in the previous spring. Soft-wood cuttings which had been planted

in the field from late April to the end of June had developed rootstocks comparable with bedded setts grown from strap cuts. These rootstocks have been replanted in the field in 1961, to assess their cropping capacity, compared with the normal bedded setts. When these results have been obtained, these experiments will be described.

HEIGHT OF WIREWORK

Cone number and distribution was examined upon three varieties of hop growing at different heights and spacing. Close spacing reduced the number of mature cones, particularly on laterals on the lower parts of the bines. Wider spacing increased the cone number, but where the plants were grown on low wirework this resulted in a very dense head system. This study is described more fully on page 67.

IRRIGATION

The irrigation experiment at Bodiam, carried out with the co-operation of Guinness Hop Farms Ltd., was repeated. Owing to a wet season, in which rain repeatedly brought the soil back to field capacity in June, July and August, little irrigation was applied and results between irrigated and non-irrigated treatments were not significant. This experiment is continuing.

DORMANCY AND ENVIRONMENT

During the winter and early spring, a series of experiments were carried out to examine the effect of low temperatures upon breaking the dormancy of hop rootstocks. Also the effect of downy mildew infection upon the food reserves of the dormant rootstock were studied in co-operation with Dr. Coley-Smith. These experiments are described on page 48.

ENGINEERING RESEARCH FOR THE HOP CROP

REVIEW OF THE YEAR'S WORK

P. H. BAILEY* and M. W. SHEA

THIS work was carried out by the Mechanical Engineering Department of the National Institute of Agricultural Engineering in close collaboration with Wye College.

PICKING MACHINES

(a) Work has continued on the use of a commercial type picking machine for harvesting hop experiments. Comparison of the results from half-plots of the height of wirework experiment picked by hand and by machine was continued on similar lines to the previous year, but the number of fractions into which the samples were sorted was decreased and the number of replicate samples increased. Results were available from all three varieties, and the statistical analysis was carried out by computer at Rothamsted Experimental Station, permitting investigation of the effect of machine picking on a wider range of variables than previously. It is clear that in the wet conditions of the 1960 harvest the yields indicated by machine picking were distinctly lower than those indicated by hand picking, in contrast to the results obtained in 1959. Variability of the machine picked results was again, if anything, slightly better than that of the hand picked results, except for the variety Northern Brewer, where the variability of the yield results was distinctly greater for the machine picked sample. This work is discussed in more detail on page 59.

(b) The performance of the picking machine was measured running at four different rates on Bullion, and mass balances drawn up for the material passing through. Surprisingly, there was no great difference recorded in the picking and cleaning performance over the range investigated, from 2.2 to 10.6 strings/min. nominal. A fuller account is given on page 72.

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HOP WIREWORK

(a) *Hop Wire Tensions.* The new stirrups were put in the height of wirework experiment in March, and satisfactory records were obtained throughout the growing season. The increase in load with growth of the crop, and temporary increases due to rain and wind were all clearly shown. There is a tendency towards higher storm loadings with the higher wirework, but not a very marked one.

(b) *Corrosion by Copper Sprays.* Small-scale observation trials showed that while Bordeaux mixture seriously attacked hop wire, copper oxychloride and colloidal copper covered the wire with deposit, but did not cause serious corrosion. No start has yet been made on the experiment envisaged to permit quantitative comparison of the rate of corrosion of galvanized wires with different copper preparations. Contact has been made with the Hot Dip Galvanizers Research Association (Zinc Development Association), and the Sulphate of Copper Association who have both shown interest. Some samples of 7×00 wire from various sources have been tested for thickness of galvanizing and all have been found to be in accordance with B.S.443:1961.

(c) *Strength of "knots" and splices.* Two separate approaches, one from Wye College, led to a short investigation being undertaken of the tensile strength at low rates of loading of various splices for joining hop wires and knots for securing wires to anchor rods. In general, the strength of the joins was found to be less than that of the wires, and in some instances considerably less. The results were thought of sufficient interest for a ten-minute film of the failures to be made. This work is discussed more fully on page 78.

THE TESTING AND SELECTION OF GOLDING CLONES

PROGRESS REPORT 1

F. H. BEARD and F. C. THOMPSON

SUMMARY

A trial of different clonal stocks of Golding-type hops is described. The aim of the trial is to select, primarily on the basis of yield and resin content, a small number of clones which will give a spread of season for harvesting. Results are given for the period 1958-1960, and the evidence to date suggests that a suitable succession of clones, under Wye conditions, would be Early Bird A6, Eastwell Golding A2, Cobbs A9 and Mathon 3/91.

INTRODUCTION

This trial of different clonal stocks of Golding hops aims at selecting those showing the best cropping performance allied to high resin content and other desirable qualities. A further object is the classification of early, mid-season and late clones. The origins of the present Wye selections of Golding clones, have been discussed in an earlier report (1955).

The clones selected for trial total 23, eight being early and 15 mid-season clones. Included in the latter are four clones of Cobbs, which though strictly a Golding Variety, has many of the characteristics of the true Golding.

The trial, which was planted in Silks Garden in 1957, is of random block design, with four replications.

EARLY CLONES

Crop Yield, Dry Matter Content and Resin Content

Samples for resin analysis were taken in each of the three years 1958-1960, and dry weight yields were recorded in 1959 and 1960. The dates of harvesting were 5th September 1958, 26th August 1959, and 8th September 1960. Table 1 gives a summary of the yield and dry matter data. The resin analysis results are summarized in Table 2.

It may be seen from Tables 1 and 2, that six of the eight clones have given similar results for yield and resin content, the two exceptions being Early Bird A4 and Bramling T9.

TABLE 1
YIELD AND DRY MATTER CONTENT OF EARLY GOLDING CLONES

Clone	Yield cwt./acre dry hops			Dry matter %	
	1959	1960	Mean	1959	1960
Early Bird A4	18.37	18.61	18.49	24.75	19.06
A6	21.19	20.28	20.74	24.24	16.94
A10	22.18	19.84	21.01	23.11	17.64
EM	21.31	21.24	21.28	23.62	17.78
Bramling P4	19.07	20.42	19.75	22.53	17.07
P6	19.44	21.33	20.39	22.88	17.84
T8	20.78	20.71	20.75	23.66	17.99
T9	16.08	21.44	18.76	20.00	19.84

TABLE 2
RESIN CONTENT OF EARLY GOLDING CLONES. MEAN VALUES EXPRESSED AS A PERCENTAGE OF DRY MATTER

Clone	Total soft resins				Alpha acids			
	1958	1959	1960	Mean	1958	1959	1960	Mean
Early Bird A4 ..	18.83	9.88	18.24	15.65	8.25	5.39	7.34	6.99
A6 ..	14.91	9.14	11.84	11.96	6.92	4.45	4.90	5.42
A10 ..	14.47	7.23	12.31	11.34	6.69	4.10	5.49	5.43
EM ..	14.14	7.20	11.81	11.05	6.68	4.11	4.98	5.26
Bramling P4 ..	13.98	7.47	11.88	11.11	6.50	4.44	5.10	5.35
P6 ..	14.02	7.60	13.28	11.63	7.14	4.47	5.60	5.74
T8 ..	14.63	7.92	12.59	11.71	6.66	4.69	5.22	5.52
T9 ..	11.80	6.28	10.36	9.46	5.35	3.54	4.18	4.36

Early Bird A4 has given a significantly higher resin content than the other clones, throughout the period of the experiment, but this has been associated with a significantly lower yield. In spite of this, however, it should be noted that the calculated yield of resin per acre has been higher than that produced by the other clones.

Bramling T9 has been found to ripen appreciably later than the other clones, an observation supported by the significantly lower dry matter content found in 1959 when the eight clones were harvested at the same time. In consequence the yield of dry hops obtained from this clone in 1959, is likely to have been unduly low, and in 1960 it was harvested approximately one week later than the other clones. The resultant yield was comparable with that from six of the other clones and well above the yield from Early Bird A4, but, somewhat surprisingly, this later picking did not enhance resin content.

In both 1959 and 1960 there was an indication of a negative correlation between the yield of dry hops and resin content, which was more pronounced in 1960. In neither year, however, did the correlation approach significance.

Apart from Bramling T9, little difference in season has been found among these clones. If anything, the Early Birds, particularly A4, tend to be slightly earlier than the Bramlings.

Market Assessment

Box samples of dried hops were prepared for market valuation in each of the three years 1958 to 1960.

In 1958 it was stated that there were no obvious differences between the clones on appearance, but on aroma, Early Bird A10 and Bramling P6 were preferred.

In 1959 comments were more general but preferences were expressed for Early Bird A4, A6, and EM, in that order.

In 1960 the top three clones were Early Bird EM, Bramling T8 and Early Bird A6 respectively.

TABLE 3
YIELD AND DRY MATTER CONTENT OF LATER GOLDING CLONES

Clone				Yield cwt./acre dry hops			Dry matter %	
				1959	1960	Mean	1959	1960
Cobbs	A9	..	..	26.04	25.87	25.96	26.41	18.61
	B3	..	..	21.37	26.78	24.08	26.30	18.79
	B8	..	..	22.40	24.18	23.29	26.01	18.75
	T10	..	..	23.74	21.17	22.46	25.31	19.15
Canterbury Golding	B3	..	..	21.51	21.04	21.28	25.75	19.13
	B9	..	..	21.14	21.20	21.12	25.94	18.99
	A2	..	..	24.01	25.00	24.51	25.70	19.73
Eastwell Golding	B2	..	..	21.11	18.87	19.99	25.59	18.47
	EM	..	..	22.15	22.47	22.31	25.48	18.68
	L3	..	..	23.13	21.74	22.44	25.35	19.80
Mathon	EM	..	..	21.91	24.38	23.15	25.37	19.41
	3/91	..	..	23.71	21.58	22.65	24.49	19.17
Petham Golding	EM	..	..	21.24	21.28	21.26	24.01	18.98
Rodmersham Golding	B1	..	..	23.23	18.93	21.08	24.83	17.50
	EM	..	..	24.54	19.16	21.85	24.83	18.09

Incidence of Downy Mildew Infection

For Goldings, the incidence of downy mildew infection has so far been generally light, and there has been no evidence of any significant variation in attack.

TABLE 4
RESIN CONTENT OF LATER GOLDING CLONES EXPRESSED AS A PERCENTAGE OF DRY MATTER

Clone		Total soft resins				Alpha acids			
		1958	1959	1960	Mean	1958	1959	1960	Mean
Cobbs	A9	12.98	10.79	10.09	11.29	5.67	6.60	4.87	5.71
	B3	12.23	9.31	10.34	10.63	5.38	5.80	4.93	5.37
	B8	12.12	9.09	9.33	10.18	5.18	5.55	4.41	5.05
	T10	12.28	9.31	10.88	10.82	5.49	5.47	5.15	5.37
Canterbury Golding	B3	12.39	7.92	9.94	10.13	5.32	4.88	4.68	4.96
	B9	14.13	9.21	10.73	11.36	6.29	5.68	5.19	5.72
	A2	12.95	8.95	9.53	10.48	5.61	5.55	4.51	5.22
	B2	13.30	8.26	10.84	10.80	5.78	5.18	5.07	5.34
Eastwell Golding	EM	11.44	9.93	7.93	9.77	4.53	5.25	3.57	4.45
	L3	12.28	9.44	11.80	11.17	5.41	5.71	5.44	5.52
	EM	11.67	8.69	9.08	9.81	4.91	5.32	4.20	4.81
	3/91	13.56	10.42	11.93	11.64	5.57	6.31	5.46	5.78
Petham Golding	EM	11.52	9.57	10.84	10.64	5.49	5.82	4.96	5.42
Rodmersham Golding	B1	12.87	8.47	10.87	10.74	5.76	5.19	5.09	5.35
	EM	11.76	7.64	9.74	9.71	5.25	4.70	4.36	4.77

TABLE 5
INCIDENCE OF DOWNY MILDEW INFECTION IN LATER GOLDING CLONES

Clone	No. of spikes			* Percentage of rootstock infection					
	1959		1960	1959		1960		Mean	
			Total	Hills	Straps	Hills	Straps	Hills	Straps
Cobbs	1	8	1	nil	nil	nil	nil	nil	nil
	8	nil	8	nil	nil	nil	nil	nil	nil
B3	3	nil	3	nil	nil	nil	nil	nil	nil
B8	15	5	20	2.5	0.4	7.5	3.5	5.0	2.0
T10	61	12	73	7.5	3.5	5.0	2.1	6.3	2.8
B3	54	11	65	7.5	4.3	15.0	4.7	11.3	4.5
B9	17	7	24	7.5	1.1	7.5	3.2	7.5	2.2
A2	34	2	36	5.0	0.7	7.5	4.2	6.3	2.5
B2	3	6	9	2.5	0.3	nil	nil	2.5	0.3
EM	62	5	67	12.5	3.6	10.0	6.7	11.3	5.2
L3	28	2	30	20.0	6.4	10.0	5.4	15.0	6.0
EM	30	4	34	12.5	4.7	5.0	3.3	8.8	4.0
3/91	27	7	34	7.5	3.2	5.0	1.4	6.3	2.3
EM	37	7	44	7.5	1.7	5.0	1.4	6.3	1.6
Petham Golding	57	3	60	7.5	1.8	10.0	8.0	8.8	4.9
B1									
Rodmersham Golding									
EM									

* As assessed by the numbers of hills and straps "cutting brown".

LATER CLONES

Crop Yield, Dry Matter Content and Resin Content

The clones were harvested on 21/22 September 1958, 7/8 September 1959, and 11/12 September 1960.

A summary of the results obtained for yield and dry matter content, in 1959 and 1960, is given in Table 3; resin analysis data for the three years 1958-1960, are summarized in Table 4.

It can be seen from Tables 3 and 4 that the outstanding clones for consistently high yield and resin content are Cobbs A9 and Eastwell Golding A2. By contrast, the Rodmersham clones, which yielded well in 1959, cropped badly in 1960. Of the remaining clones Canterbury Golding B9 and Mathon 3/91 have maintained consistently high resin contents, but have given relatively poor *average* yields.

In 1959, there was no evidence of any correlation between yield and resin content, but in 1960 there was an indication of a small, but statistically non-significant, negative correlation.

Seasonal Order of Burr and Cone Development

Records are taken each year of the dates of burr formation and cone development and though, with one exception, differences in season are not marked, there is a graduation from the relatively early Cobbs A9 and Eastwell Golding L3 clones to the relatively late Mathon 3/91 and Eastwell Golding B2 clones. The exception is Eastwell Golding A2, which is appreciably earlier than all the others, being of similar season to Bramling T9.

Market Assessment

As with the early clones, box samples of dried hops were prepared for market valuation, in each of the three years 1958 to 1960.

In 1958, no very obvious differences between the clones were recorded, but preferences were expressed for Rodmersham B1, Cobbs T10, Mathon 3/91 and Eastwell B2.

In 1959, the most favourable comments were made on the two Canterbury Golding clones, B3 and B9, followed by Rodmersham B1, Mathon 3/91, Cobbs T10 and Cobbs B8. The East Malling (EM) clones of Rodmersham and Eastwell, received adverse comments.

In 1960, a more detailed market assessment was made, allotting marks for aroma, appearance and side. On this basis, the top four

clones were Mathon 3/91, Eastwell A2, Eastwell EM and Mathon EM, in that order. Cobbs B8 and Eastwell L3, received the poorest marks.

Incidence of Downy Mildew Infection

Table 5 shows the incidence of downy mildew infection, as measured by "spike" production and rootstock infection, in 1959 and 1960. In 1958 spikes were not prevalent until June and July and were then distributed uniformly throughout the different clones.

It can be seen from Table 5 that the Cobbs clones have shown much less downy mildew in the rootstock than any of the Golding clones, with the exception of Eastwell Golding EM. The two Canterbury Golding clones have shown the least resistance to infection, confirming past experience with this Golding.

CONCLUSIONS

From the results to date, the indications are that among the early clones, Early Bird A4 will be slightly earlier in season and appreciably higher in resins, but lower in yield, than the others. The Early Bird clones as a group are likely to be slightly earlier than the Bramblings, and of the latter, T9 is relatively late and should only be considered as an early mid-season hop.

Of the later clones, Cobbs A9 and Eastwell Golding A2 are the most promising on yield and resin content and have received satisfactory or good market assessments; both are relatively early in season. Mathon 3/91 has been outstanding for resin content and market assessment, but has not cropped so well; it is relatively late in season.

On the evidence to date a suitable succession of clones, under Wye conditions, would be Early Bird A6, Eastwell Golding A2, Cobbs A9 and Mathon 3/91. It should be emphasized that these are provisional conclusions only and that no planting material of these clones is available at present.

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THE EFFECT OF LIGHT INTENSITY AND LEAF AREA UPON THE ROOTING OF SOFT-WOOD CUTTINGS OF THE HOP (*HUMULUS LUPULUS* L.)

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SUMMARY

Work carried out in a glasshouse at Wye showed that the growth and rooting of soft-wood cuttings of the hop plant were markedly influenced by light during propagation under mist. The growth rate and rate of rooting was better under high light conditions than under conditions of heavy shade. Propagation using mist techniques has a distinct advantage over traditional propagation in a closed frame. A possible explanation is that too high a temperature builds up in the closed frame which retards root production.

These investigations have emphasized the importance of the rate of photosynthesis upon the regenerative capacity of the cuttings.

INTRODUCTION

The technique of propagation involving the use of mist which has been developed over the last two decades has been described as "mechanical and controlled syringing" (Rowe-Dutton, 1959). It permits the rapid regeneration of soft-wood cuttings and is particularly effective with species which do not root readily when the traditional method is used of enclosing the cuttings in a propagation frame and watering them by hand. Its application in research should be fully appreciated for it is a reliable method for producing rapidly a large number of plants from an initially small stock where clonal material is required in quantity for research purposes. A constant and predictable supply of rooted cuttings is easily achieved with relatively little attention because the method lends itself to a considerable degree of automation.

Mist techniques involve the use of an automatically controlled intermittent spray. This wets the leaf surface and maintains a thin film of water which keeps the leaf turgid even when the cuttings are exposed to the highest intensities of natural light available in a glasshouse. On the other hand cuttings enclosed in a propagating case or closed frame require heavy shading at least in the early stages to avoid wilting.

It was found by Watling (1957) in a preliminary study that the dry weight increase and rooting of penstemon cuttings, and

cuttings of *Chamaecyparis fletcheri*, under mist was positively related to light intensity.

Before effective rooting can take place it is probable that a net balance of photosynthates is required over and above those utilized in respiration (Hess and Snyder, 1955).

The aim of these experiments was to examine the effect of light intensity upon the growth and rooting of cuttings (a) under mist and (b) in a closed frame, and to assess the importance of photosynthesis as a factor in the regeneration of soft-wood cuttings.

MATERIALS AND METHODS

Source of material

The hop (*Humulus lupulus* L.) var. Eastwell Golding was used, of which large quantities of clonal material suitable for soft-wood cuttings were available. Earlier work (Williams and Sykes, 1959) indicated that the environmental conditions during the propagation period greatly influenced the rate of regeneration of soft-wood cuttings of this plant. Cutting material from vegetative laterals was obtained from mature plants in the field. The two basic types of cuttings used were those described by Williams and Sykes (1959) and will be referred to as "two-node" and "leaf-bud" cuttings. A modified leaf-bud cutting, with the leaf trimmed to a standard size was also used, Fig. 1a, b, c. The type of mist installation is described as the inbed system.* Two benches, 4×33 , and $3\frac{1}{2} \times 33$ feet long were used, running north-south in a large glasshouse. Misting nozzles were set at 40 inches apart and were 22 inches above the rooting medium. A pump regulated the water pressure. The hydrostat was situated in a non-shaded area of the bench and consisted of two carbon electrodes embedded in an ebonite block.

The ambient temperature, dependent upon prevailing weather conditions, was measured by a thermograph on the bench 2 inches above the rooting medium. The minimum night temperature was 55° - 60° F. during most of the experimental period. Bottom heat was supplied by soil warming wires loaded at 15 watts per square foot to give a minimum night temperature of between 68° and 72° F., at a depth of 1 inch in the rooting medium.

The rooting medium consisted of sharp sand (approximately 0.3/16 grist) and horticultural peat in the ratio of 2 : 1 by volume.

* As designed and marketed by MacPennys Mist Propagation, Bransgore, Hampshire.

Shading structures

Different shade treatments were applied by using three wooden frameworks each covering 40×48 inches of the mist bench. Each framework was placed centrally 7 inches above a mist nozzle, giving adequate spray clearance. The framework was covered with heavy grade (500) polythene, shading to within 8 inches of the bench on three sides and to within 15 inches on the north side. The light intensity was modified by adding layers of white rayon cloth to the three structures. The polythene lining prevented excess moisture saturating the rayon. This design permitted uniformity of light intensity within the area used beneath each structure and also achieved maximum air circulation at the different levels of shading.

Levels of shading were selected to give a wide range of light intensities, which were estimated by using a photo-electric cell. It was assumed that the unshaded bench received the maximum quantity of available incident light within the glasshouse. The following average values for the light intensities under the different structures were then obtained (Table 1).

TABLE 1

Treatment	% Light and shading materials used
1. (Open bench)	100
2. (Light shade)	63 (polythene only)
3. (Medium shade)	28 (polythene + 1 layer rayon)
4. (Heavy shade)	9 (polythene + 4 layers rayon)

Propagating Frame

A comparison with a typical glazed propagating frame was also made as treatment No. 5. The frame, $42 \times 38 \times 10$ inches high at the front, was constructed on the bench, with the sloping roof facing east, beyond the range of the misting nozzles. The rooting medium and bottom heat in the frame were the same as in the mist bench. Cuttings in the frame were watered using a fine rose can, daily at 9 a.m. and more frequently when necessary. To maintain turgidity a hessian cover was laid over the glass of

the frame as described by Professor Salmon (Beard and Wilson, 1946). Cuttings in this frame received 8 per cent. of the available light, but during very dull periods this shading was partially or completely removed to give a total value throughout the experiments in excess of this figure of 8 per cent.

Recording

The growth of the cuttings was assessed in terms of the increase in dry weight during the course of each experiment. Dunn and Went (1959), working with tomato plants, state that "the dry weight is a reasonably accurate measure for the net photosynthesis (photosynthesis minus respiration)". It is therefore a measurement suitable for cuttings rooting in a peat/sand mixture of low nutrient status for a period of about ten days, when measurable changes in dry weight are due to net photosynthesis. Throughout each experiment the degree of root development was estimated both visually and by a dry weight assessment.

In each experiment twenty cuttings were selected at random as the sample from each treatment. Sampling was usually carried out every second day throughout the experiment. The mean dry weight of the cuttings prior to each experiment was obtained by taking at random five batches of 20 cuttings and drying these to constant weight in an electric oven thermostatically controlled at 95° C. Drying was carried out for 24 hours, after trials had shown this period to be satisfactory.

Changes in weight during each experimental period were determined by sampling 20 cuttings per treatment as described above.

A scoring method was used to give a visual assessment of the stages of regeneration. This was done by placing each rooted cutting in one of 12 groups according to number and length of roots present. These ranged from cuttings which had callused to well-rooted cuttings with more than 20 roots over 2 cm. long.

STANDARDIZATION OF CUTTING MATERIAL

A series of five experiments was conducted to determine the effect of different light intensities upon the regenerative capacity of hop cuttings under mist and in experiments 2-5 the propagating frame was used for comparison. It became increasingly evident, however, in the course of these five experiments, that it was necessary to eliminate other factors which may also influence the rate of regeneration of a cutting. Two additional experiments

were therefore made to determine the effect of leaf size upon the rate of rooting, and the importance of the physiological age of the cutting as indicated by its original position on the lateral.

Leaf-bud cuttings were used and groups of cuttings of three different ages were obtained by selecting them from the proximal, median and distal portions of the laterals. Table 2 shows the average leaf areas of cuttings from each of the three age groups.

TABLE 2
AVERAGE LEAF AREAS IN SQUARE CM.

Proximal cuttings (old)	Median cuttings (intermediate age)	Distal cuttings (young)
19.9	50.2	18.2

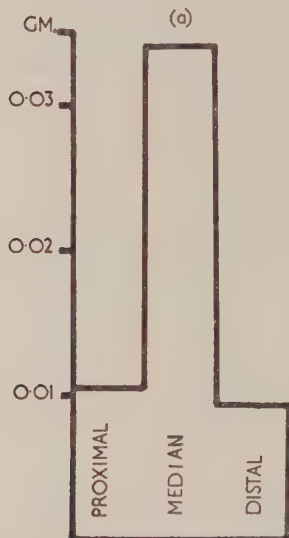
Thirty cuttings from each of the three age groups were inserted in the bench in three randomized plots of 10 cuttings each. After 10 days these were removed and the dry weight of roots produced was recorded.

In a further experiment to determine the influence of leaf area upon the rooting rate, cuttings from the three age groups were inserted in the bench as described above, but all the leaves were trimmed to 9 square cm. (Fig. 1c). The dry weight of roots produced was recorded after 10 days.



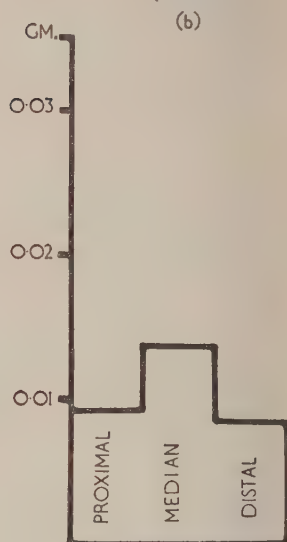
FIG. 1

DRY WEIGHT OF ROOTS
PER CUTTING (MEAN OF 30)



LEAVES UNTRIMMED

DRY WEIGHT OF ROOTS
PER CUTTING (MEAN OF 30)



LEAVES TRIMMED

FIG. 2

Fig. 2a shows that the greatest dry weight of roots was produced by cuttings with large leaves which are of intermediate age and found mid-way along the lateral. It is seen in Fig. 2b that by removing the leaf size factor the differences in rooting between the three groups of cuttings is considerably reduced, although some subsidiary factor is still operative which causes cuttings of intermediate age to root somewhat better. Plate 1 shows the effect of age and leaf size upon rooting.

When these results were obtained the type of cutting used in the main series of experiments was modified to eliminate such factors as leaf size and age of cutting. This enabled the effects of the light intensity treatments to be studied with greater accuracy.

EXPERIMENTAL RESULTS

Experiments 1-3 inclusive ran consecutively from 28th June, 1960, until 1st August, 1960. Basically these experiments were



PLATE 1

To show the effect of leaf size and original position on the lateral upon root development. 1. Proximal. 2. Median. 3. Distal. The effect of trimming the lamina to a uniform size is to reduce the variability in root production.

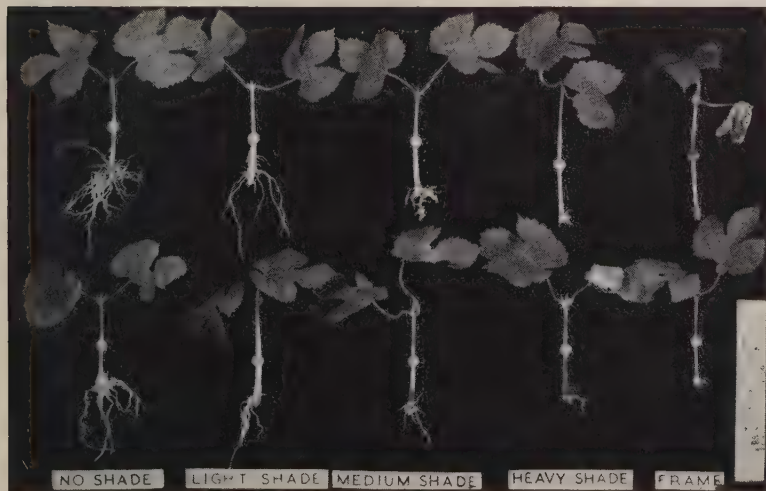


PLATE 2

The effect upon rooting when cuttings under mist are subjected to various levels of shade and also rooted in a propagating frame.

similar and the two-node type of cutting, visually selected for uniformity, was used throughout (Fig. 1a). Sixty cuttings were inserted in each treatment for experiment 1 when samples were made each fourth day during the 12-day rooting period. After this initial experiment it was found that a 10-day rooting period was sufficient to secure the rooting of all cuttings and so experiments 2 and 3 each lasted for 10 days and samples were made from each treatment every second day. The positions of the shading structures on the mist bench were changed between experiments 2 and 3 and the frame treatment (No. 5) was included.

Results show that the dry matter content of the cuttings increased while under mist. The rate of this increase was greatest in the non-shaded treatment (No. 1) and lowest in the heavy shade treatment (No. 4) (Fig. 3a, b, c). Cuttings from the propagating frame increased least in dry matter content and often lost weight relative to their initial dry weight prior to insertion in the frame (Fig. 3b, c).

Root initials were generally visible by the fourth day, more cuttings in the higher light intensity treatments having produced root initials by this time than in the more heavily shaded treatments. Similar trends were observed for rooting as for the dry weight increase of the leaves and stem (Fig. 3f, g, h). The greatest dry weight and number of roots was produced by cuttings in the non-shaded treatment and the production of roots decreased as the depth of shading was increased. Cuttings in the propagating frame rooted poorly and the leaves of a few of these cuttings wilted and died. No wilting occurred under mist. The effect of the treatments may be seen in Plate 2.

It was evident from these experiments that the light intensity under which cuttings were rooted was a critical factor both for growth (on the basis of dry weight increase) and rate of rooting. To reduce the effect of the varying leaf and stem sizes of the two-node cuttings upon the dry weight estimations, and to differentiate more clearly between treatment effects, experiment 4 was designed using leaf-bud cuttings (Fig. 1b). These have a much larger ratio of leaf to stem and the effect of treatments which influence the photosynthetic behaviour of the cutting would be intensified.

Experiment 4 was begun on 18th August, 1960, when 100 leaf-bud cuttings were inserted in each of the five treatments. Samples were taken each second day for a period of 10 days.

Results were similar to those obtained in previous experiments. The influence of the various treatments was more clearly seen

**DRY WEIGHT INCREASE PER CUTTING (MEAN OF 20)
INCLUDING ROOTS WHEN PRESENT**

**DRY WEIGHT OF ROOTS PRODUCED
PER CUTTING (MEAN OF 20)**

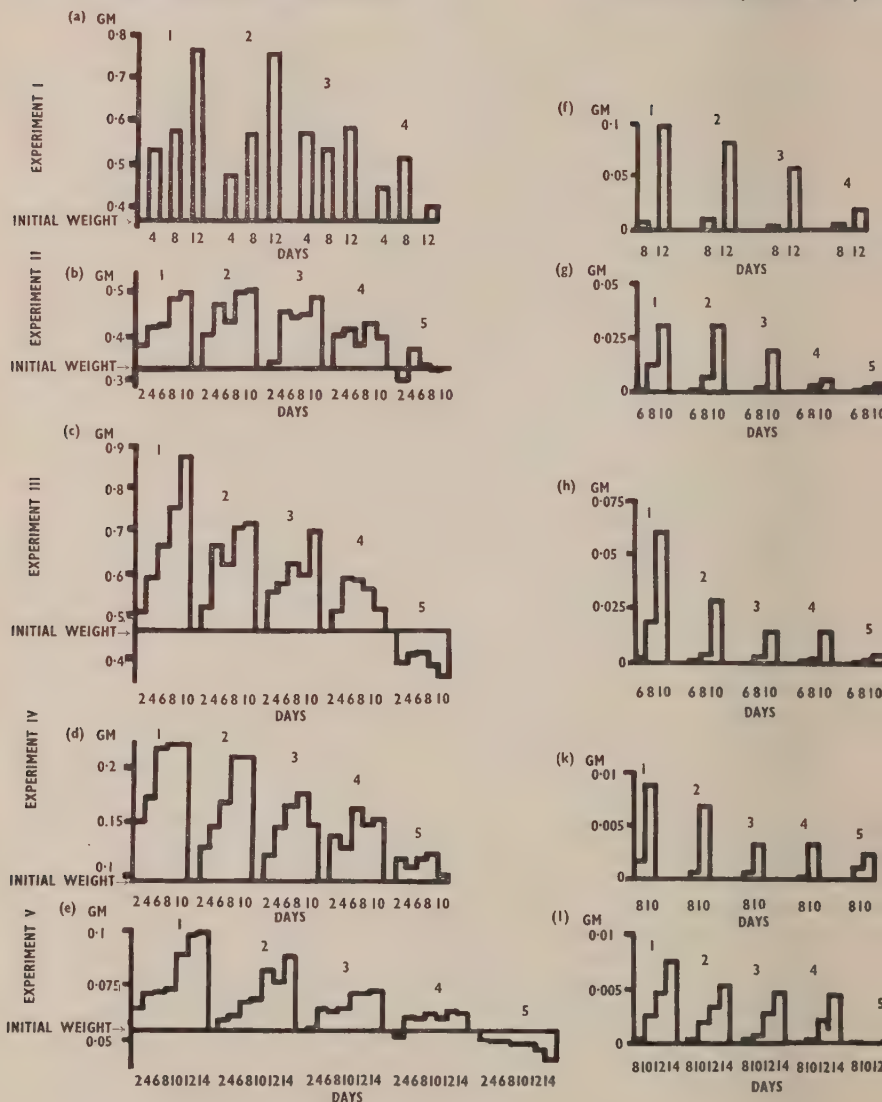


FIG. 3

To show the effect of various shade treatments upon the changes in dry matter content, and root development of hop cuttings under mist. Figures above the columns indicate the treatments, 1-100%, 2-63%, 3-28%, 4-9% available light. Treatment 5 is the hand-watered propagating frame receiving 8% light. Figures below the columns indicate the sampling days within each experiment.

both in the dry weight increases of leaf and stem, and the dry weight and number of roots produced (Fig. 3d, k). No loss of weight occurred relative to the initial dry weight of the cuttings before insertion in the bench.

A further increase in the uniformity of cutting material was made in experiment 5 in this series when 140 trimmed leaf-bud cuttings were inserted in each treatment on 29th August, 1960. The cuttings which were selected for size were also trimmed by reducing the leaf to a rectangle 7 square cm. in area by cutting off the lobes of each leaf (Fig. 1c). Any small difference in leaf size between cuttings was thus removed, but the ratio of leaf to stem was again reduced. Preliminary work showed that smaller cuttings were longer in reaching the optimum state of rooting and so this experiment was designed to run 14 days with 20 cuttings sampled from each treatment on each second day.

The effect of the series of light intensities upon the dry matter content of the cuttings was again marked. Cuttings receiving the maximum available light in the glasshouse increased in dry weight at the greatest rate and as the depth of shading increased the rate of dry weight gain decreased (Fig. 3e). Similarly, the number and dry weight of roots produced was relative to the amount of light received (Fig. 3l).

Although in each of the experiments described above the light intensity within the propagating frame was comparable with that of treatment No. 4 (heavy shade), other environmental conditions were different. Growth and rooting of cuttings was not comparable between these different environments, and some cuttings in the frame developed marked chlorosis, while some rotted and died. These results are probably explained by a marked temperature difference between the two treatments. The minimum night ambient temperature within the propagating frame was consistently 8-10° F. higher than that over the mist bench where the application of water in the form of a spray caused further cooling of the cuttings. This suggests that temperature may be important as a subsidiary factor and experiments are being carried out at present under controlled growth room conditions to examine the effect of temperature upon the rate of rooting of misted cuttings under constant light intensity.

DISCUSSION AND CONCLUSIONS

The capacity of this variety of the hop to root from soft-wood cuttings is high when the propagating technique involving mist

is used. In most of the experiments described here, 100 per cent. of the cuttings rooted even under the least favourable treatment of the shaded frame, therefore this plant provides almost ideal material to examine the interaction of different environmental factors during propagation upon the rate of regeneration. This is of considerable fundamental interest, but is also of value from a practical standpoint, since it is important that conditions in the propagation house should be aimed at obtaining successful regeneration in the shortest time.

These experiments have shown that the primary advantage of the mist technique is that the soft-wood cuttings of hop can remain under good light conditions whilst leaf turgor is maintained and photosynthesis can proceed during regeneration. Closed frames require shading to maintain humidity in the early stages of regeneration and this inevitably reduces the light factor and hence the rate of regeneration.

In considering the interaction of light and photosynthesis two other factors must be examined, namely, the area of leaf and the physiological age of the leaves on the cutting. In the later experiments an attempt was made to reduce variability due to these factors, at first by using the leaf-bud type of cutting selected only from the middle portion of laterals of comparable age and finally, by reducing the leaf in all cases to a standard leaf area. The results from these experiments show more clearly the importance of light as a factor in the rate of regeneration.

Another approach to this problem would be to use a growth room in which light conditions would be definable and reproducible. Under glass it is only possible to design the shading treatments in such a way that the regimes of light intensity do not overlap. Further work using growth rooms is in progress and it is also proposed to examine more critically the influence of temperature upon regeneration.

ACKNOWLEDGMENTS

The writer wishes to acknowledge the facilities provided for this work by the Department of Hop Research, Wye College, especially the advice and help given by Dr. I. H. Williams of that Department, and by Mr. J. T. Sykes of the Department of Horticulture, Wye College.

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STUDIES OF THE DORMANT PHASE OF THE HOP (*HUMULUS LUPULUS* L.)

I. H. WILLIAMS, J. B. ROBERTS, J. R. COLEY-SMITH

SUMMARY

The onset of dormancy of the hop is initiated by short days. During this process food reserves accumulate in the storage roots and the overground shoot system dies. Before dormancy can be broken a period of low temperature is necessary, after which vigorous shoot growth proceeds even in the short days experienced in spring. During the breaking of dormancy there is a gradual conversion of starch to soluble sugars. Rootstocks inoculated with downy mildew showed a depletion of food reserves during the dormant period and this may account for the lack of vigour of diseased plants in the spring.

INTRODUCTION

The term "dormancy" may be defined as "the temporary suspension of visible growth" (Samish, 1954). "Winter dormancy" is a complex process, since plants in this condition appear to be prevented from further growth by internal inhibitory factors, so that growth is not readily renewed even under favourable external environmental conditions. This form of dormancy is common to many temperate perennial plants as a means of survival through seasonal periods unfavourable to growth when the processes of photosynthesis are not possible due to adverse climatic conditions. It appears to involve two major stages; the "onset of dormancy", during which the more vulnerable parts of the plant such as leaves, shoots, and fine roots may be discarded, and some form of protected resting buds developed. This stage may be regarded as complete when the plant will not readily make new growth if given good growing conditions. The second stage, the "breaking of dormancy" involves the gradual removal of growth inhibition and is considered complete when the resting buds break into new growth when climatic conditions permit and the plant renews its photosynthetic organs.

Between late August and late October growth and development of the shoot system of the hop ceases and the shoots gradually die back to near to soil level.

From late October to late March or early April the overwintering hop plant consists of a rootstock, comprising a number

of thick perennating roots, the basal portion of the previous season's shoots, and resting buds which will develop into the shoot system and carry the crop in the following growing season.

In common with other perennial temperate plants, food reserves are accumulated in the roots of the hop plant during one season's growth and are utilized in the subsequent season's growth. The present paper describes a series of experiments designed to examine these processes during this dormant phase. For completeness, an earlier experiment on the onset of dormancy is summarized in Section 1 but this paper is mainly concerned with the changes which occur after dormancy has been established and before new shoot growth is resumed (Section 2). In Section 2, the interaction between the plant and the environment is described; the normal biochemical processes which occur during this period are discussed and an experiment examining the effect of downy mildew infection upon food reserves during the dormant phase is described.

SECTION 1. THE ONSET OF DORMANCY

SUMMARY OF RESULTS

Williams and Weston (1958) demonstrated that the onset of dormancy of the hop plant in the autumn is a complex, regulated process, initiated by the changes in daylength. It involves, in addition to the gradual death of the shoot system and of the finer roots, the transfer and accumulation of food reserves in the storage roots and the development of relatively large resting buds on the perennating portion of the shoot system below soil level. In these experiments young plants of the variety Eastwell Golding, grown in a warm glasshouse throughout the winter, continued vegetative shoot elongation under long days (natural daylength extended by the use of H.P.M.V. lamps to sixteen hours). These plants developed large fibrous root systems containing little storage material. In contrast, plants grown in the same temperature, but under the naturally shortening days of autumn, had all ceased vegetative shoot growth by early September. The leaves remained viable until late October or early November though gradually senescing. During this period a considerable amount of storage material, mainly starch, accumulated in the roots, which increased in thickness up to a centimetre in diameter; the fibrous roots died and large dormant buds developed on the basal shoot portion below soil level. By early November the shoot system had died completely to near to soil level. Results are summarized in Fig. 1.

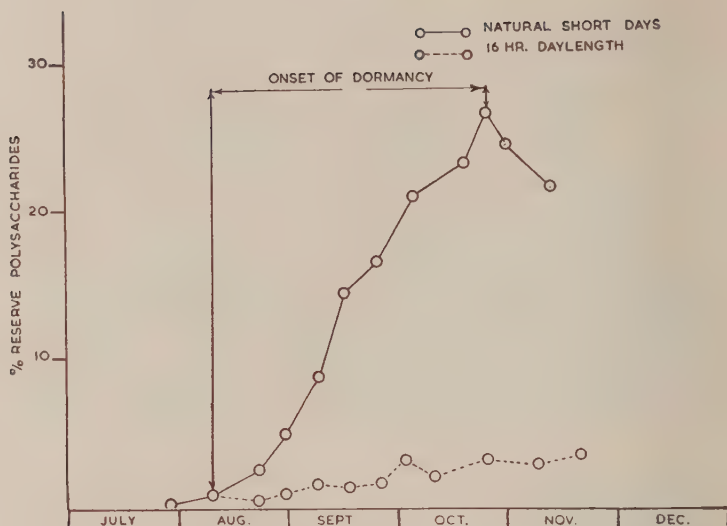


FIG. 1
Changes in food storage. Reserve Polysaccharides.

SECTION 2. THE BREAKING OF DORMANCY

MATERIALS AND METHOD

In all the experiments described below a standard type of material was used. Soft-wood cuttings of the variety Eastwell Golding were propagated under glass at the beginning of July and were grown on in 5½ inch pots and stood in the open until mid-September. They were then removed to a heated glasshouse with a minimum temperature of 45° F. By late October the overground shoot system had died. The experimental material therefore consisted of relatively small dormant rootstocks well supplied with resting buds.

THE EFFECT OF NATURAL AND ARTIFICIAL LOW TEMPERATURE

For this experiment, two groups of plants received the following treatments:

- (a) 50 plants were removed from the glasshouse in pots to a standing ground in the open at the end of October 1960. Three plants were brought into a growth room, maintained

at 65° F and a daylength of 9 hours, at weekly intervals until the end of January 1961, in order to assess the effect of successively longer periods of natural low temperatures upon the breaking of dormancy.

- (b) 50 rootstocks were washed free of soil and placed in polythene bags in a refrigerator maintained at a temperature of 38° F. Three plants were removed from the refrigerator at weekly intervals from November to the end of January, potted up, and placed in the growth room described above to compare the effect of artificial low temperature upon the breaking of dormancy.

RESULTS

(a) *Natural low temperature* (Table 1)

Plants brought into the growth room from the open during November remained dormant throughout the subsequent period of the experiment. Those brought in during early December behaved similarly. One plant, brought into the growth room on 14th December made some shoot growth, but this ceased when the shoots were about 30 cm. in length. Plants brought in on 20th December all developed elongating shoots but, as with the plant previously described, this shoot growth was not maintained, and the shoots ceased growth at between 20 and 40 cm. Plants which had remained in the open until 2nd January 1961 all developed vigorously elongating vegetative shoots within fourteen days of their

TABLE 1

Date brought into Growth Room 65° F. 9 hrs. D/L	Effect of natural low temperature (3 plants at each sampling)	Effect of artificial low temperature 38° F no light. (3 plants at each sampling)
4 Nov. 1960	Remained dormant	Remained dormant
11 " "	" "	" "
18 " "	" "	" "
25 " "	" "	" "
2 Dec. "	" "	" "
14 " "	One plant made some shoot growth	Shoots developed fully
20 " "	All plants made limited shoot growth	" " "
2 Jan. 1961	Shoots developed fully	" " "
9 " "	" " "	" " "
16 " "	" " "	" " "
27 " "	" " "	" " "

removal to the growth room. Subsequent batches behaved in a similar manner; shoot elongation was maintained and it was evident that despite the mild winter, plants of this variety growing in the open appeared to have received a sufficient period of low temperature to break dormancy.

(b) Artificial low temperatures (Table 1)

Rootstocks from the refrigerator maintained at 38° F which were potted up and moved into the growth room in November, failed to make new shoot growth. Plants removed from the refrigerator on 14th December developed vigorous shoots and thereafter all the plants brought into the growth room from this artificial low temperature treatment grew away strongly. It was evident that six weeks at 38° F was sufficient to break the dormancy of this variety.

CARBOHYDRATE ANALYSES

Rootstock samples from the natural low temperature treatment were used for analysis. The samples were divided into root and the basal perennating portion of the shoot, and each cut into thin slices and dried in a vacuum desiccator over silica gel. Five rootstocks were taken at each sampling date from November onwards, and their root and shoot portions separately bulked to provide samples for analysis. The dried slices were ground to a powder in a small laboratory mill and the ground samples stored at room temperature.

Analyses were carried out to determine the content of methanol-soluble sugars and of starch in each sample.

The powdered sample (2 g.) was extracted with three portions of 80% methanol at room temperature, and the combined extracts made up to 250 ml. This solution was used for soluble carbohydrate determination by the anthrone colorimetric method (Yemm and Willis, 1954) after precipitation of interfering polyphenols and proteins with lead acetate solution. The solid residue from the extraction was used for starch determination. The samples were hydrolyzed in dilute hydrochloric acid, and the liberated reducing sugars determined by the Somogyi method (Association of Official Agricultural Chemists, 1960).

RESULTS

The results of these analyses are shown graphically in Fig. 2. The sharp rise in percentage starch in mid-October coincides with

the senescence of the aerial parts of the plant and the transference of food reserves into the rootstock. The subsequent fall in percentage figures in October is accounted for by secondary thickening of the roots to accommodate this sudden increase in reserves. The graphs also show that the decrease in starch content during November and December is balanced by a corresponding increase in the soluble carbohydrates. Thus in the period 26/10 to 21/12, starch content falls from 23% to 16% in the root, whilst the corresponding figures for soluble carbohydrates show an increase from 6% to 13%.

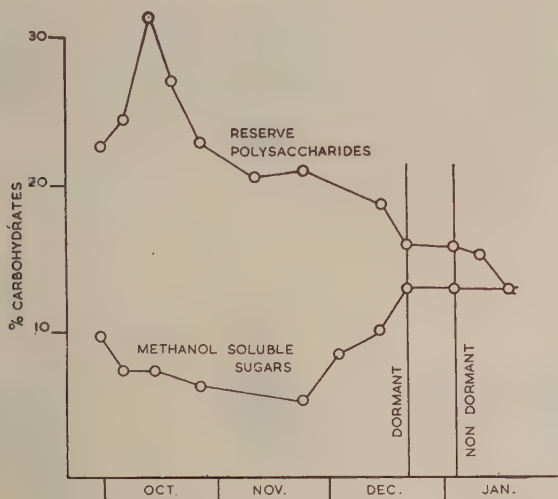


FIG. 2
Changes in food storage. Breaking of Dormancy.

There is therefore very little change in the total of carbohydrate reserves during the dormant phase, but there is a change in the nature of the reserves. The relatively insoluble starch which is initially present is gradually converted into more soluble, and therefore more readily available sugars, during this period. Between late December and early January, when bud inhibition appeared to be removed, the percentage of soluble carbohydrates had increased almost to the level of the starch, indicating that a rich supply of food material was available for subsequent shoot development when dormancy was completely broken.

THE EFFECT OF DOWNY MILDEW DISEASE ON THE CARBOHYDRATE CONTENT OF DORMANT HOP ROOTSTOCKS

Infection by downy mildew disease is known to bring about a progressive weakening of rootstocks of susceptible varieties. This has been found to be associated with a loss in yield (Beard and Derbyshire, 1957).

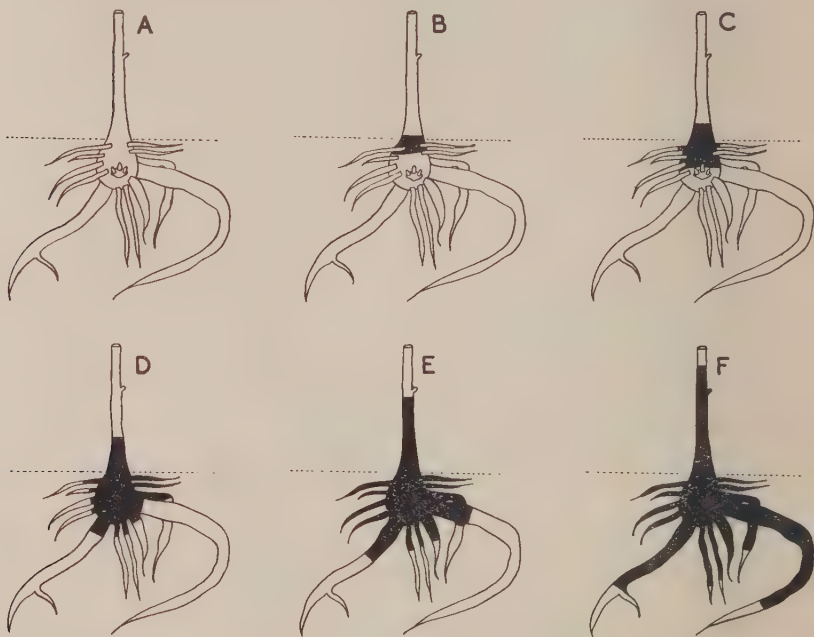


FIG. 3.

Growth of *Pseudoperonospora humuli* following inoculation of rootstocks of Eastwell Golding. The diseased area is shown in black. The dotted line indicates the soil surface. A. 1 week after inoculation (28th September), B. 2 weeks (5th October), C. 3 weeks (12th October), D. 1 month (19th October), E. 5 weeks (26th October), F. 7 weeks after inoculation (9th November).

During the course of anatomical investigations on the overwintering of *Pseudoperonospora humuli* it was noted that hop storage roots contain large numbers of cells packed with starch grains. In downy mildew-diseased roots starch grains were often absent. In view of this an experiment was carried out to discover the effect of downy mildew on the carbohydrate status of small pot rootstocks.

Pot plants of Eastwell Golding were inoculated by pouring 25 ml. sporangial suspension (20,000 sporangia/ml.) on to the soil surface around the base of the bine. The inoculations were done in mid-September and the plants thereafter kept outside under natural conditions. Samplings were made at intervals to determine the progress of the disease anatomically (Coley-Smith, 1960) and for chemical analysis. Five inoculated and five control plants were examined in each sample. The pattern of infection is shown in Fig. 3. The fungus was first located, a fortnight after inoculation, at the base of the current year's bine. After this it grew in both upward and downward directions until early November when the rootstocks were more or less completely colonized. The tissues gradually disintegrated and in January when the rootstocks were badly rotted samplings were discontinued.

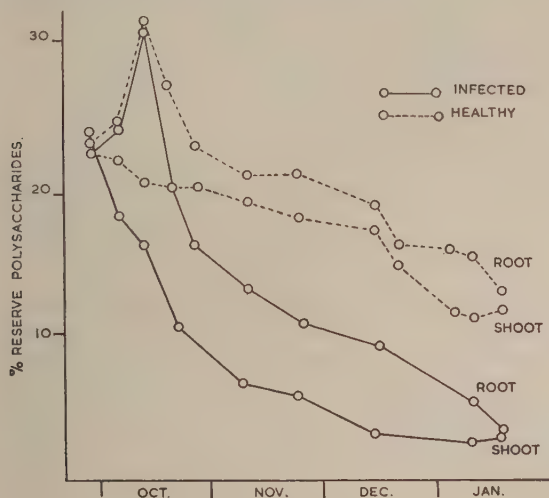


FIG. 4

The effect of downy mildew disease on the reserve Polysaccharide content of hop rootstocks.

The disease had a marked effect on the reserve polysaccharide and soluble sugar levels. The "starch" content of the infected rootstocks fell much more rapidly than that of the control plants (Fig. 4). This effect occurred first and was more rapid in the diseased shoot than in the root. There was also a fall in soluble sugar content of the diseased plants following inoculation, this

effect also being observed first in the shoot. In the uninoculated controls there was a sustained rise in soluble sugar content following the onset of cold weather. In the diseased plants this rise occurred before that in the controls but was not sustained and the soluble sugar content subsequently fell again (Fig. 5).

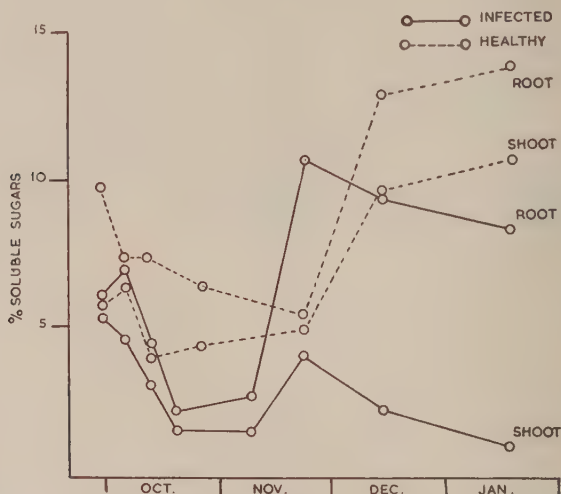


FIG. 5
The effect of downy mildew disease on the methanol soluble sugar content of hop rootstocks.

Analyses of strap cuttings of Northern Brewer taken from field plants in February also showed that the soluble sugar and reserve polysaccharide content of diseased plants was lower than that of healthy plants.

CONCLUSIONS

The onset of dormancy of the hop, measured as the cessation of shoot growth, appears to be primarily a short-day response, beginning in late August and completed by late October or early November. During the greater part of this period the leaves remain viable although the shoot system gradually senesces. Active photosynthesis appears to continue until a late stage during this period and soluble sugars are translocated to the root system where they are stored, primarily as starch. Other changes which occur include the conspicuous enlargement of the resting buds upon the short

perennating section of the shoot close to soil level, the discarding of the fine root system and the thickening of storage roots to accommodate the reserve polysaccharides. From early November onwards, shoot growth can only be stimulated with considerable difficulty until the rootstocks have received a period of low temperature, which removes the inhibitory effect upon the resting buds. Rootstocks brought in from the standing ground in the open resumed active shoot growth in a good growing temperature in early January. This growth was sustained under the short-day conditions of a growth room, indicating that dormancy was "broken".

In the refrigerator, dormancy was effectively broken after about six weeks at 38° F. From the time when the shoot system died back in early November, the percentage of reserve polysaccharides began to fall. Earlier experiments have shown that this occurs also with more mature plants growing in the open (Williams, 1959). Analysis carried out in the present experiments indicated that the decrease in reserve polysaccharides was largely balanced during the breaking of dormancy by a comparable increase in soluble sugars. This suggests that very little of the food reserves are used up to sustain the plant during this phase but that there is a gradual conversion of reserves to a more soluble form to supply the energy substrate for subsequent shoot growth in spring.

The downy mildew fungus *Pseudoperonospora humuli*, overwinters in this country as mycelium in infected hop rootstocks. Badly affected plants are usually less vigorous than healthy ones and their yield is consequently lower. This lack of vigour has also been noted with pot plants where healthy shoots frequently arise from diseased rootstocks, but such shoots are always weaker than those of healthy plants. The present work provides, at least in part, an explanation for these effects in that it shows that following infection the reserve polysaccharides and soluble sugars in hop rootstocks quickly become depleted.

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HEIGHT OF WIREWORK AND SPACING TRIAL NO. II: SECOND PROGRESS REPORT

PART 1. CULTURAL DATA AND COMPARISON OF HAND AND MACHINE PICKING

F. C. THOMPSON and P. H. BAILEY*

INTRODUCTION

A report on the results obtained in the first year of this trial, in 1959, appeared in the previous Annual Report (Thompson and Bailey, 1960), when the objects of the trial and the experimental design were described. In 1960, the design was modified slightly, the hand- and machine-picked half plots being randomized, so that statistically valid comparisons could be made between the two picking methods. The experimental procedure was similar to that used in 1959, but the number of samples taken for sorting and dry matter determination was increased from three to four for the machine-picked material, and from two to four for the hand-picked material. To offset this, time was saved in sample sorting by reducing the number of categories from six to four. The 1959 results had shown that the "petal and seed" fraction was a better index of damage than the "broken hop" fraction, so the latter was combined with the "whole hop" fraction; the "leaf" and "stem" fractions were similarly combined. The "foreign matter" heading was retained, but as in 1959, the amounts collected were negligible.

The machine was again run slowly with every other clamp loaded, and was run empty between plots. The input rate in strings per minute was approximately 4.5, rather less than in 1959, but because of heavier yields the output of green hops was higher. A study of the performance of the machine at different input rates (page 72) suggested that this change involved no important difference in picking performance.

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RESULTS

Yield

In contrast to the result obtained in the warm dry harvest of 1959, the wet conditions and heavy crops of 1960 produced a highly significant decrease in yield of clean dry hops by machine picking as compared with hand picking, for all three varieties. It was observed that there was an appreciable number of unpicked hops on the stripped bines, and a quantitative investigation of these and the hops rejected by the cleaner was included, for the variety Bullion, in the study of the performance of the machine at different input rates (page 72). It may be noted that the green weight of hops per string was more than one and a half times that in 1959. Table 1 shows the mean results both for clean dry hops and for "total dry hops"—the latter value includes leaf and stem present in the sample, but both are on an oven-dry basis.

TABLE 1
OVERALL MEAN YIELDS, LB. PER PLANT

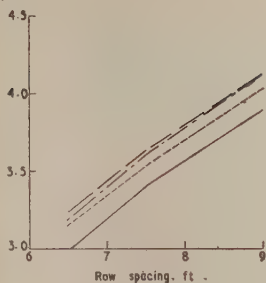
Variety	Fuggle N		Northern Brewer		Bullion	
	Machine	Hand	Machine	Hand	Machine	Hand
Clean dry hops	2.86	3.09	2.91	3.20	3.43	3.59
Total dry hops	3.09	3.19	3.12	3.31	3.64	3.67

Inclusion of the larger amount of leaf and stem in the machine-picked material in "total dry hops" tends to mask the yield differences, but in Fuggle and—in particular—Northern Brewer, the yield differences for picking method are still perceptible. It was noted that the Northern Brewer produced many large cones which were rejected by the cleaner of the picking machine because of the policy of working with a fixed setting, and this is considered to be the main reason for the larger difference in yield between the two picking methods with this variety: it is obvious that in future the setting of the machine must be altered to accommodate such varietal characteristics.

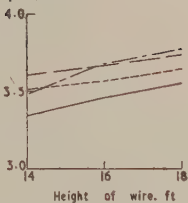
In spite of the differences in overall mean yield between picking methods, the trends indicated by hand picking for response to height of wirework and spacing were in general reproduced by machine picking, as shown in Fig. 1. Spacing effect is highly

Bullion

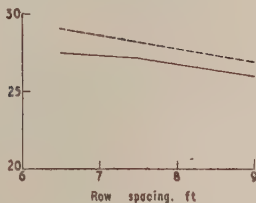
Yield per
plant, lb.



Yield per
plant, lb.

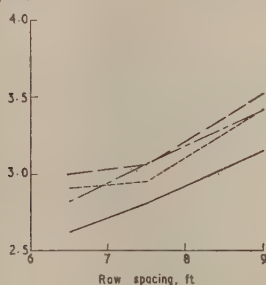


Yield per
acre, cwt.

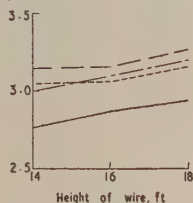


Fuggle N

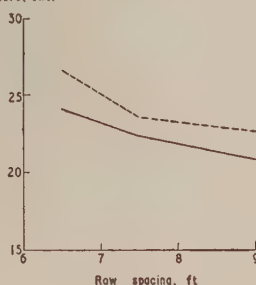
Yield per
plant, lb.



Yield per
plant, lb.

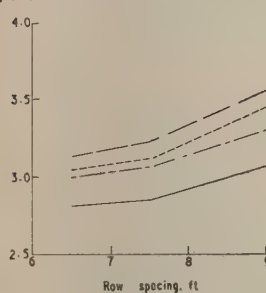


Yield per
acre, cwt.

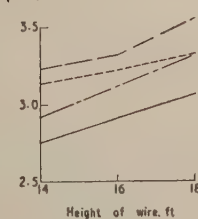


Northern Brewer

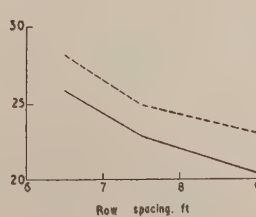
Yield per
plant, lb.



Yield per
plant, lb.



Yield per
acre, cwt.



Key:

Total dry hops

Machine picked

Hand picked

Clean dry hops

Machine picked

Hand picked

FIG. 1

significant for all three varieties with hand picking, and for Fuggle and Bullion with machine picking, but is not quite significant with machine-picked Northern Brewer. There are no significant effects of height on the hand-picked hops, but there is a significant trend to higher yield with the higher wirework for machine-picked Fuggle and Bullion.

The tendency to decreased yield per acre with increased spacing was highly significant for hand-picked Fuggle and Northern Brewer, but the increase in yield per plant was such as almost to compensate for the reduction in plants per acre with Bullion, and the yield decrease indicated by hand picking was not significant. With machine picking, the decrease in yield with increased spacing was highly significant for all varieties.

Composition of Samples

It can be seen from Table 2 that data calculated on a total dry hop basis show a marked decrease in mean total soft resin and alpha acids contents for machine picking compared with hand picking, which is significant for all three varieties. As would be expected, correction of these results to a clean dry hop basis reduces the differences.

TABLE 2
OVERALL MEAN RESIN CONTENTS

Variety		Fuggle N		Northern Brewer		Bullion	
Picking method	..	Machine	Hand	Machine	Hand	Machine	Hand
% <i>total dry hops</i> :							
Total soft resin	..	9.86	11.11	13.81	14.71	14.93	15.74
Alpha acids	..	4.06	4.73	7.06	7.74	6.61	7.07
% <i>clean dry hops</i> :							
Total soft resin	..	10.68	11.48	14.80	15.18	15.85	16.16
Alpha acids	..	4.40	4.89	7.57	7.99	7.02	7.26

Neither hand picking nor machine picking indicated any consistent tendency for resin contents to vary with height of wirework or spacing. Results for weight of resin per plant and weight of resin per acre in general reproduced the yield results, but with generally lower levels of significance because of the additional dispersion introduced by the resin sampling factor.

Table 3 shows the mean proportions of the various physical fractions of the hops, expressed as percentages. The lower dry matter contents compared with 1959 reflect the wet picking conditions. The petal fraction was slightly higher for machine-picked hops than in the previous year, indicating greater breakage, but slightly less for the hand-picked hops, so that the differences are more marked. A similar trend is shown for the "leaf and stem" fraction (previously called "total impurities").

TABLE 3
MEAN PHYSICAL COMPOSITION OF SAMPLES

Variety	Fuggle N		Northern Brewer		Bullion	
Picking method ..	Machine	Hand	Machine	Hand	Machine	Hand
D.M. content of green hops %	16.9	17.2	20.0	20.4	22.0	22.2
Petal, % of d.m. ..	11.1	3.2	5.4	1.2	4.6	0.8
Leaf and stem, % of d.m.	7.7	3.2	6.7	3.1	5.8	2.6

There was a significant effect of spacing on leaf and stem content for hand-picked Fuggle, the material from the wider spacing being cleaner, and a significant effect of height for machine-picked Bullion, the *lower* wirework apparently producing a cleaner crop. These isolated results should be treated with reserve. As in 1959, there was no significant effect of height or spacing on petal content, but the effect of height approached significance for machine-picked Fuggle, and the results for Fuggle and Bullion showed a similar overall trend to that of the previous year, as shown in Table 4.

TABLE 4
EFFECT OF HEIGHT ON PETAL CONTENT, EXPRESSED AS A PERCENTAGE OF TOTAL DRY HOPS

Variety	Fuggle N		Northern Brewer		Bullion	
Picking Method ..	Machine	Hand	Machine	Hand	Machine	Hand
Height 18 ft. ..	9.7	2.50	5.8	1.35	4.4	0.72
16 ft. ..	9.7	3.12	5.3	1.03	4.0	0.75
14 ft. ..	13.8	3.97	5.1	1.08	5.4	0.83

COEFFICIENTS OF VARIATION

In order to compare the variability of the data obtained by the two picking methods for the various factors investigated for each variety, coefficients of variation are set out in Table 5. Instead of a coefficient based on the combined error variance as in the previous progress report, separate coefficients are shown based on the standard error with respect to the whole plot treatments, i.e. heights (*a*) and with respect to the sub-plot treatments, i.e. widths (*b*).

TABLE 5
COEFFICIENTS OF VARIATION

Variety	Fuggle N		Northern Brewer		Bullion	
Picking method ..	Machine	Hand	Machine	Hand	Machine	Hand
Error (<i>a</i>)						
Yield per plant, clean						
dry hops	0.014	0.016	0.071	0.021	0.009	0.017
Total dry hops ..	0.008	0.018	0.084	0.023	0.009	0.015
Dry matter content ..	0.037	0.082	0.037	0.036	0.040	0.055
Petal content ..	0.073	0.221	0.167	0.173	0.140	0.296
Leaf content	0.099	0.111	0.188	0.041	0.012	0.201
Total soft resins ..	0.048	0.050	0.080	0.079	0.060	0.015
Alpha acids	0.002	0.055	0.070	0.098	0.075	0.037
Error (<i>b</i>)						
Yield per plant, clean						
dry hops	0.035	0.050	0.065	0.025	0.023	0.052
Total dry hops ..	0.035	0.050	0.060	0.028	0.020	0.050
Dry matter content ..	0.076	0.037	0.134	0.105	0.094	0.115
Petal content ..	0.083	0.161	0.109	0.202	0.214	0.254
Leaf content	0.179	0.209	0.146	0.140	0.106	0.123
Total soft resins ..	0.046	0.069	0.101	0.084	0.053	0.062
Alpha acids	0.089	0.049	0.082	0.070	0.059	0.052

With Northern Brewer, the coefficient of variation for yield was much higher for machine-picked hops than for hand-picked, and this may be attributed to the fact, previously mentioned, that the machine was wrongly set for this variety. For the other two varieties, the coefficients of variation were slightly lower for machine picking than for hand picking.

The general level of the coefficients of variation was distinctly

lower than in 1959, in spite of the difficult harvest conditions, and this can probably be attributed at least in part to the improvement in sampling technique, and in particular to the increased number of samples taken.

DISCUSSION

In the rainy conditions of the 1960 harvest in Kent, the use of the picking machine gave results for yield and for resin content that were consistently less than those obtained by hand picking. Variability was in general slightly reduced by machine picking, and the use of either picking method would result in approximately the same overall conclusions being reached about the effect of height of wirework and spacing on yield and resin content. In two instances, for Fuggle N and Bullion, a significant trend to higher yield with higher wirework was found for machine-picked hops which was not present with hand-picked hops, probably partly because of the lower variability of the machine-picked results and partly because of an interaction between height of wirework and machine picking; the interaction was not significant, however.

It may be noted that the results for yield of total dry hops showed similar trends to those for clean dry hops, and the variability of the results was similar. For the purposes of the experiment on the effects of height of wirework and spacing on yield, it would appear that sorting samples from all plots is unnecessary, and that comparisons could be carried out on a total dry hop basis. Full sampling would still be necessary to determine dry matter content, with sampling on a reduced scale to indicate the approximate level of leaf and stem present. However, for the purpose of comparing hand and machine picking of experimental plots in all aspects it is desirable to sample at the full rate.

It may be argued that as the amount of leaf and stem included in hand-picked experimental hops in the past was unknown, it may be possible, eventually, to ignore the content of leaf and stem in machine-picked hops. Whether the amount is to be ignored or not, the results obtained with Northern Brewer suggest that it may not always be possible to work with the picking machine at fixed settings. Operators of machines used for picking experiments involving varieties of widely differing characteristics must acquire skill in making adjustments so that they can pick the bulk of the hop material with a minimum of leaf and stem.

ACKNOWLEDGEMENT

Acknowledgement is due to Mr. J. C. Gower of the Department of Statistics, Rothamsted Experimental Station, for arranging to carry out the bulk of the statistical analysis by electronic computer.

REFERENCE

THOMPSON, F. C. and BAILEY, P. H. (1960). Height of wirework and spacing trial No. II. First progress report. Parts 1-3. *Rep. Dep. Hop Res. Wye Coll. for 1959*, 54.

PART 2. A NOTE ON GROWTH AND DEVELOPMENT

I. H. WILLIAMS

INTRODUCTION

Studies were carried out in September 1960 on the varieties Fuggle N, Northern Brewer and Bullion grown on the normal umbrella stringing at two heights and at two spacings. Data were obtained on the effect of these treatments upon the distribution of mature cones up the bine.

MATERIALS AND METHODS

Six hills of each variety were selected at random from the 18 ft. high and 14 ft. high wirework. Three hills selected at each height were at the 9 ft. spacing and three at the $6\frac{1}{2}$ ft. spacing; in all cases the cross spacing was at $6\frac{1}{2}$ ft.

Each hill consisted of four strings with two bines to each string. The strings were cut at the banding-in point, approximately 5 ft. above soil level, in September when the crop was ripe. It was not feasible to separate each bine so growth analysis was carried out upon individual strings. The strings were subdivided into convenient lengths of one metre (3 ft. $3\frac{1}{4}$ in.) from the banding-in point, with the exception of the proximal section immediately below the top wire and the distal section of the bines which grow over the top wire. These portions varied with treatment and variety and are collectively referred to as the "head". All reasonably well formed cones were counted in each section so that an assessment of number and

TABLE 1
LENGTH OF TRAINING STRINGS (MEAN PER HILL)

Treatment (ft.)	Total length Ground to Top-wire		Banding-in Point to Top-wire	
	ft.	in.	ft.	in.
14 $\times$ $6\frac{1}{2}$	15	2	10	5
14 $\times$ 9	15	9	11	0
18 $\times$ $6\frac{1}{2}$	18	7	13	11
18 $\times$ 9	19	3	14	5

distribution in relation to spacing, height and variety was obtained.

The actual length of the strings from the banding-in point to the top wire in the different treatments is given in Table 1, together with the total length from the ground to the top wire.

RESULTS

Total Length of Bine—Effect of Spacing and Height

As Table 2 shows, different spacing at the same height had little effect upon the total length of the bine with either Fuggle N or Northern Brewer. There was a slightly greater increase with

TABLE 2
TOTAL LENGTH OF BINE—GROUND TO TIP
MEAN OF 3 HILLS/TREATMENT

Treatment (ft.)	Fuggle ft. in.	N. Brewer ft. in.	Bullion ft. in.
14 × 6½	18 1	18 6	17 7
14 × 9	18 7	18 11	18 9
18 × 6½	21 7	20 0	22 8
18 × 9	21 3	19 11	23 6

Bullion. The length of the bines was significantly greater on the higher wirework. Earlier studies of the rate of elongation of shoots have shown that elongation is severely checked when the shoot has grown beyond the top wire. This check is probably due largely to the "kinking" of the unsupported terminal portion. It may also be due to the effect of the loss of apical dominance of the terminal growing point as a result of the change of position of this region of the shoot from a vertical to a horizontal plane. Whatever the cause, this check to elongation and further development of the primary shoot will occur earlier on the lower wirework and will largely account for the smaller total length of the bine. In addition, this check also stimulates vigorous lateral development in the length of shoot immediately below the top wire producing a dense head system characteristic of vigorous varieties grown on low wirework. On the higher wirework the check to the growth of the primary shoot occurs later, a greater length of bine is possible and the tendency to form a dense head is reduced.

*Cone Distribution—Effect of Spacing and Height
Fuggle N (Table 3)*

The plants growing at the closer spacing produced fewer cones per bine on both heights of wirework. Fewer cones developed on the lower portions of the bines at the closer spacings. The overall increase in cone number at the wider spacing may be due in part to the advantages of reduced root competition for available nutrients and for water. Distribution of cones is however also likely to be influenced by the cutting down of light reaching the lower portions of the bines at the closer spacing and this may be further accentuated where a dense head system is formed as on the lower wirework. At 14 ft. the majority of cones at both spacings developed upon an extensive lateral system in the head region. More even distribution was found at 18 ft., laterals were shorter and cones developed more evenly throughout the length of the bine, a form of growth better suited to machine picking.

TABLE 3
CONE DISTRIBUTION—FUGGLE N

Treat- ment (ft.)	No. of cones/section above banding-in point					Total no. of cones/ string (2 bines)	Length of sec- tion of head	
	0-3 ft. 3 in.	3 ft. 3 in.- 6 ft. 6 in.	6 ft. 6 in.- 9 ft. 9 in.	Sections/head			Proxi- mal ft. in.	Distal ft. in.
				Proxi- mal	Distal			
14 × 6½	42	144	—	1165	693	2044	3 11	2 11
14 × 9	130	404	—	1875	604	3013	4 6	2 10
18 × 6½	11	189	689	1294	673	2856	4 2	3 0
18 × 9	176	414	747	1273	556	3166	4 8	2 0

TABLE 4
CONE DISTRIBUTION—BULLION

Treat- ment (ft.)	No. of cones/section above banding-in point					Total no. of cones/ string (2 bines)	Length of sec- tion of head	
	0-3 ft. 3 in.	3 ft. 3 in.- 6 ft. 6 in.	6 ft. 6 in.- 9 ft. 9 in.	Sections/head			Proxi- mal ft. in.	Distal ft. in.
				Proxi- mal	Distal			
14 × 6½	13	173	—	1341	793	2320	3 11	2 5
14 × 9	230	568	—	1944	682	3423	4 6	3 0
18 × 6½	7	76	598	1470	840	3091	4 2	4 1
18 × 9	232	319	804	1567	681	3603	4 8	4 3

Bullion (Table 4)

The pattern of cone distribution was similar to that of Fuggle. Closer spacing resulted in the development of fewer cones, particularly on laterals on the lower sections of the bines. Wider spacing largely offset this effect but wider spacing combined with low wirework resulted in the formation of a very dense head.

Northern Brewer (Table 5)

The effects of different heights and spacings upon cone number and distribution found with Fuggle and Bullion were far less marked in the case of Northern Brewer. This variety has an inherently different habit of growth, producing fewer, larger cones upon short laterals evenly distributed from the banding-in point to the tip. Wider spacing did not greatly increase the number of mature cones nor did this variety exhibit any marked tendency to form a dense head on the lower wirework.

Under our conditions of soil and culture it would appear that this variety is able to develop to full capacity and with a satisfactory form for machine picking on low wirework at fairly close planting.

TABLE 5
CONE DISTRIBUTION—NORTHERN BREWER

Treatment (ft.)	No. of cones/section above banding-in point					Total no. of cones/ string (2 bines)	Length of section of head	
	0-3 ft. 3 in.	3 ft. 3 in.- 6 ft. 6 in.	6 ft. 6 in.- 9 ft. 9 in.	Sections/head			Proxi- mal ft. in.	Distal ft. in.
				Proxi- mal	Distal			
14 × 6½	290	480	—	495	337	1602	3 11	3 4
14 × 9	361	474	—	521	342	1698	4 6	3 2
18 × 6½	206	339	455	363	163	1526	4 2	1 5
18 × 9	309	412	413	519	92	1745	4 8	0 8

CONCLUSION

The results obtained show the influence upon cone development and distribution, of spacing, height and varietal habit. Wider spacing resulted in an increase in the number of mature cones developed. With close spacing there were fewer mature cones on the lower laterals, but a larger number of small cones which would be regarded as unfit for harvesting; this effect held for both heights, with all varieties tested. This suggests that where light between the

rows was restricted, many of the cones which had begun to develop failed to reach maturity. With the vigorous growth produced by Fuggle and Bullion in the 1960 season, low wirework resulted in the development of a dense head system, further depriving the lower laterals and leaves of light. Northern Brewer, however, made weaker growth and there was little tendency for the formation of a dense head.

By contrast, high wirework produced a better form of plant for machine picking, with both Fuggle and Bullion. At 18 ft., the check to development of the main shoot occurred later and resulted in a better distribution of cones on shorter laterals over a longer length of bine. There was less tendency to form the dense head which was characteristic of these varieties on the 14 ft. wirework. With Northern Brewer, this effect was less marked, as might be expected, and emphasized the importance of varietal habit of growth, and vigour, in relation to height and spacing treatments. In this connection it should be pointed out that the wet season of 1960 favoured the growth of Fuggle and in a drier year such a marked contrast between this variety and Northern Brewer might not arise.

Finally, it should be said that cone weight was not recorded on the hills sampled and a close relation between number of cones and the yield data recorded in the main experiment, and given earlier in this report, cannot be expected because of sampling variations. It is hoped to carry out a more detailed study of this relationship in the 1961 season.

NOTE ON THE PERFORMANCE OF THE WYE COLLEGE PICKING MACHINE (ROTOBANK 275) AT DIFFERENT RATES OF OPERATION

P. H. BAILEY*

SUMMARY

The picking machine was run at various input rates, including one slower and two faster than those used in the plot-picking experiments described on page 59. The change in performance with a 1 : 4 variation of the rate was not great. Although there was a tendency for more hops to be left on the bines at the higher rates, neither the proportion of the total hops recovered nor the proportion of waste in the final sample varied greatly.

INTRODUCTION

In the experiment comparing half plots from the height of wirework and spacing trial (see page 59) picked by hand and by machine, the picking machine was run slowly and an attempt was made to deliver the maximum of hop material rather than to obtain the cleanest sample possible. With as much hop material as possible delivered, it was considered reasonable to ignore hops rejected by the machine either on the bine or in the waste streams (just as hops left on the bine by hand pickers are normally ignored) and thereby simplify the procedure for picking an experiment by machine.

To amplify the results obtained in the plot-picking experiment described on page 59 and to gain experience in testing a hop picking machine, four runs were made picking Bullion hops at different input rates, including one slower and two faster than those used for the experimental plots. The machine was set during these runs by a representative of its manufacturer. He was, however, instructed to deliver the maximum hop material to the bagging-off station as for the plot-picking experiment. The machine was run empty before and after each of the four sets of measurements and stopped while sheets were put underneath to collect material dropping through. In each run, four trailer loads of hops containing in all about 150 strings were picked, except in the slowest run when only two loads were picked. The loaded trailers were weighed on

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the N.I.A.E. Mk. 2 mobile weighbridge to determine the weight of incoming material, and the loading of the numbered clamps was checked to determine input rate. The moisture content of all material collected was determined, so that a dry matter balance could be drawn up, and all samples were sorted into two categories, "hop material" and "waste" (bine, leaf, stem, and string). The "hop material" from the hop output was also divided into hops (whole and broken) and "petal and seed".

RESULTS

A balance of dry matter was drawn up for each run in the form shown in Table 1 (for run 4) and illustrated as a flow diagram in Fig. 1. A summary of the results obtained in all four runs is given in Table 2.

TABLE 1
DRY MATTER BALANCE FOR RUN 4

Location	Hop material (lb.)	Waste material (lb.)	Total (lb.)	Total, percentage of input
Input	—	—	249.6	100
Hop output	102.0	5.5	107.5	43.0
Picked bines	3.9	51.3	55.2	22.1
Main waste	4.3	65.8	70.1	28.1
Second waste	1.0	1.0	2.0	0.8
Hand sorters	0.4	1.6	2.0	0.8
Sweepings	0.5	1.4	1.9	0.8
Total measured output	112.1	126.6	238.7	95.6
Deficit	—	—	10.9	4.4

No values are available for hop material and waste at input, because, although the incoming bines were weighed, and sampled for moisture content determination, the samples were not picked by hand to determine the proportion of hop material and waste. Consequently it is not possible to divide the deficit, or apparent loss of dry matter, between hop material and waste with any degree of certainty. In Fig. 1 and Table 2 the assumption has been made that an equal percentage of hop material and waste has been lost. Apparent loss of dry matter may arise partly from experimental error in the various measurements of weight and moisture content, and partly from unrecorded output. Small pieces of material discharged in the cleaner fan duct were not collected, but are

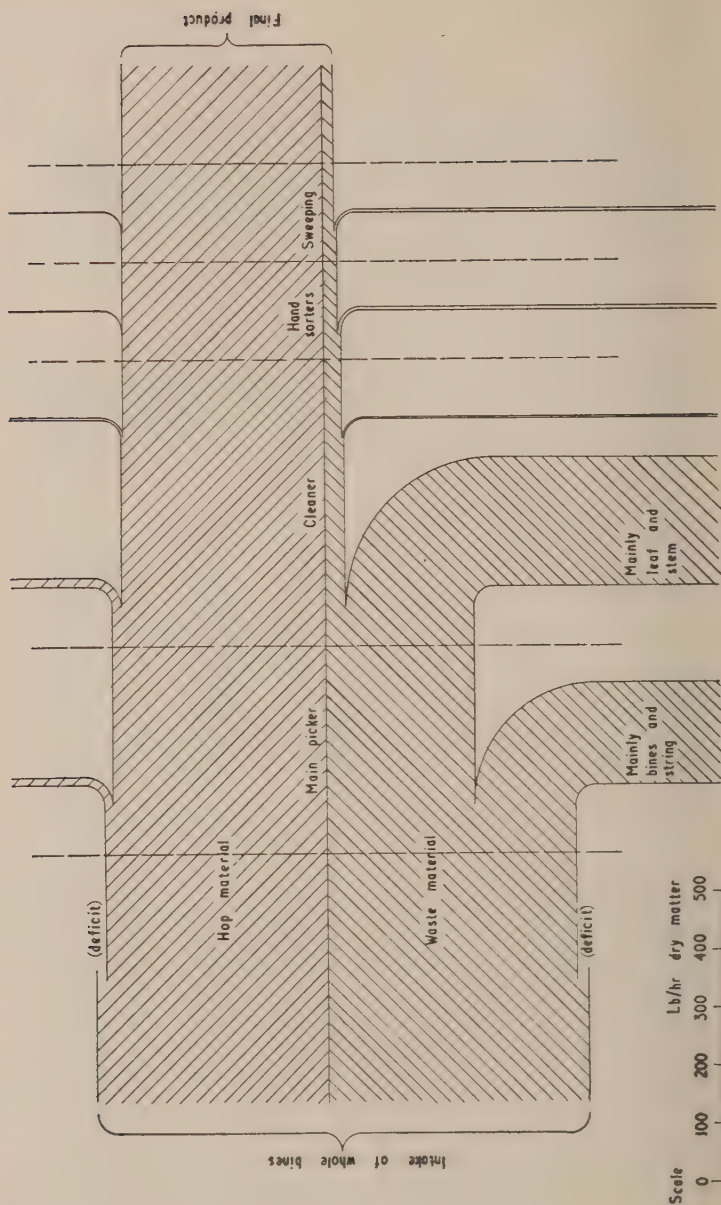


FIG. 1

unlikely to have amounted to anything like 4.4 per cent. of the input. Other possible actual losses of dry matter may have arisen from small pieces of material thrown outside the area from which "sweepings" were collected, or from resin adhering to the machine.

TABLE 2
SUMMARY OF PERFORMANCE AT VARIOUS PICKING DATES

Run No.	2	1	3	4
Clamps per minute	6.9	8.6	12.8	10.6
Clamps loaded	1/3	1/2	1/2	1/1
Nominal input rate (strings/minute) ..	2.3	4.3	6.4	10.6
Mean input rate (strings/minute) ..	2.2	3.9	5.8	8.9
Output of clean dry hops at hop outlet (lb./hr.)	91	165	231	350
Apparent loss of dry matter (per cent.) ..	4.9	0.7	3.0	4.4
Recovery of hops:				
Percentage delivered at hop outlet ..	93.2	92.2	89.9	90.9
" left on bines	1.7	2.7	2.3	3.5
" in main waste	2.9	3.4	6.0	3.9
" at other outlets	2.2	1.7	1.8	1.7
Composition of final sample:				
Hop material (Hops, per cent.) ..	87.2	89.9	84.5	91.7
" (Petal and seed, per cent.) ..	4.5	3.8	6.3	3.2
Waste (leaf and stem, per cent.) ..	8.3	6.3	9.2	5.1
Leaf and stem picked out by hand sorters, per cent. of leaf and stem delivered to sorting table	—	25	—	22
Crop conditions:				
Hops (per cent. of dry weight recovered)	47.8	46.1	46.6	47.0
Moisture content of input (per cent.) ..	75.9	78.6	75.8	76.8
Moisture content of hop output (per cent.)	77.2	79.8	77.2	78.2
Moisture content of picked bines (per cent.)	73.1	75.1	73.9	74.9
Moisture content of main waste (per cent.)	75.1	75.6	73.6	75.0

DISCUSSION

When the machine was working very slowly, with only every third clamp loaded, the time taken in changing trailers was of relatively little consequence, so the actual mean input rate (determined from the total number of strings and the total time for the run) approached the nominal input rate. With increasing input rate the time taken for changing trailers, during which additional clamps entered the machine unloaded, occupied an increasing

proportion of the total run time until at 10·6 strings/min. nominal rate, the actual rate was only 84 per cent. of the nominal rate. In each case, however, the machine worked for a large part of the test period at a capacity approaching that represented by the nominal input rate.

The change in performance with a variation of output rate over a range of 1 : 4 is not as great as might have been expected, changes in setting of the machine apparently having compensated for the greater loading of the picking and cleaning mechanisms in the faster runs. Although the recovery of hops at the main outlet was best at the slowest input rate, the petal and leaf and stem fractions in the final sample were smallest at the highest input rate, and this result was not achieved at the expense of rejecting an especially large amount of hop material from the cleaner. There appears to have been a tendency for more hops to be left on the bines at the higher input rates, which is possibly related to the number of clamps loaded: with every third clamp loaded 1·7 per cent. of the total hops recovered were left on the bine, with every second clamp loaded 2·7 per cent. and 2·3 per cent. were left, and with every clamp loaded 3·9 per cent. were left. It is not possible to explain the generally poor performance in run 3 (5·8 strings/min. actual), when the wastage of hops was unusually high and the analysis of the final sample was unusually bad, and it can only be assumed that the setting in this run was unfortunate.

It is of interest to compare the composition of the final sample in run 1 with the mean composition of the final sample for machine picked Bullion in the experiment comparing half-plots picked by hand and machine (see page 59). Here petal was 4·6 per cent. and leaf and stem 5·8 per cent.—a similar result allowing for experimental error. If the value of percentage of total clean dry hops delivered at the hop outlet determined in run 1 can also be taken to apply, then it would appear that the total yield of clean dry hops per plant was

$$3.43 \times \frac{100}{92.2} = 3.72 \text{ lb.}$$

The yield indicated by hand picking was 3·57 lb. per plant, indicating that 4·2 per cent. by weight of the total hops were not collected in hand picking, compared with 7·8 per cent. in machine picking, for this variety. Too much importance should not, however, be attached to the precise numerical values given here for these losses, which depend on the results of a single test run.

Data on the amount of leaf and stem picked off the final inspection conveyor by the four sorters must be treated with reserve because it is only available for runs 1 and 4, as the material rejected by them was accidentally mixed with the sweepings in runs 2 and 3. It is immediately noticeable from Table 2 that the amount of leaf and stem they removed was only about a quarter of that in the sample at delivery to the conveyor, and that the proportion did not change with a 1 : 2 change in output of hops. Observation suggested that the sorters removed nearly all the large and prominent pieces of leaf and stem, and that the remaining three-quarters left in the final sample consisted mainly of small pieces that it would be impossible to remove by hand without a prohibitively large number of hand sorters. The four existing hand sorters may, however, be economically justified if they remove large pieces of waste which might otherwise lead to the down-grading of a sample. The amount of hop material rejected by the hand sorters was obviously small, consisting mainly of small hops attached to large pieces of stem, and the amount shown in Table 1 for run 4 is probably not typical.

Data on crop conditions have been recorded in Table 2 partly to indicate conditions and partly for their intrinsic interest. It will be noted that the moisture content of the hops delivered was higher, and that of the picked bine and waste streams lower, than the moisture content of the whole bines before picking. The proportion of the total dry weight which consisted of hop material was approximately 47 per cent., and as the strings accounted for roughly 3 per cent. of the total, the commonly accepted notion that hop material accounts for approximately one-half of the total weight of the bine is confirmed.

With regard to testing procedure, it was considered that the results obtained were of a satisfactory degree of accuracy, the values of apparent loss of dry matter being commensurate with those normally obtained in tests of driers for green material. It was found that too great a disturbance was caused to the normal work of the machine by stopping to clean up between runs. It is therefore considered desirable to carry out further test runs, on a continuous basis, with rates of input and discharge recorded (not necessarily simultaneously) instead of total amounts. Any full test of a picking machine should include at least one run picking Fuggle, as this is not only still the most common variety, but one which is difficult to pick satisfactorily and which should therefore provide the most stringent test.

NOTE ON TESTS OF HOP WIRE FASTENINGS

P. H. BAILEY* and E. P. COLEMAN*

SUMMARY

Tests were made on wire and joints commonly used in hop garden wire-work. The anchor wire examined had ultimate tensile strengths of 2 to 2·38 tons. The most usual method of fixing to the anchor eye slackened at less than half the ultimate strength of the wire itself when tested at a relatively slow rate of loading.

INTRODUCTION

As a result of an enquiry concerning a commercial wire fixing it was decided that some information on the behaviour of commonly used joins and fastenings would be necessary, to assess the merits of the commercial fastening.

Some samples of anchor wire, described as 00×7 , and complete joins and fastenings were obtained from two sources. These were in the form used in the field, except that the anchor shank was reduced in length to suit the testing machine.

METHOD OF TEST

The tests were made in a hydraulically-operated tensile testing machine with wedge grips for the wire ends and the load was applied as fast as the testing machine permitted, but it was not possible to reproduce a snatch load which might correspond to a severe gust of wind. In no case did failure occur in the wedge grips and in some instances it was possible to observe the elongation in the wire under load, but with a made-up join the overall strain observed was a combination of strains in the wire and compaction of the join.

RESULTS

Anchor Wire

The wire from the two sources, although apparently similar, had ultimate strengths which ranged between 2·0 and 2·38 tons and it would appear that the specification of the wire allows for

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considerable variation. Elongation before failure was about 15 per cent. on a 12-inch gauge length. The material appeared to be galvanized mild steel.

Fixings to Ground Anchors

(a) A common method of fixing the wire to the anchor eye is by passing the wire through the eye and twisting the free end backwards and round the standing part of the wire to form loose turns spaced apart. A number of these fixings were tested and all started to unwind at about 0.7 to 0.9 tons. Unwinding continued without any increase in load until the wire separated from the eye. Thus the maximum load carried by this form of fixing was less than half the ultimate strength of the wire.

(b) Another method of forming the same type of fixing uses a simple tool to produce a tightly wound spiral with turns touching. This fixing showed the same tendency to unwind at a low load (0.7 to 0.9 tons), and while some examples formed a knot while unwinding and were able to resist heavier loads the fixing could not be relied upon to do so.

(c) A third method of fixing, less commonly used, consists of separating one of the seven strands in the tail of the wire and wrapping it round the standing part of the wire and the remainder of the tail with each turn tightly against the last, then taking another strand and wrapping it similarly, and so on until only a single strand of the tail remains, which is wrapped round the standing part of the wire. Several examples of this type of fixing were tested; in one case the fixing held and the standing part of the wire broke at its full ultimate tensile strength, while the others failed at a minimum load of 70 per cent. of the ultimate tensile strength.

(d) Some splices and fixings were tested using bulldog grips consisting of a U-bolt into which the wires could be clamped by a bridge piece tightened on to the wire. These were a simple and reliable method of making a fastening provided the method of attachment and spacing recommended in BS.462:1958 was followed.

Anchor fixings made by passing the wire through the eye and clamping the free end to the standing part with three bulldog grips withstood loads of 1.8 to 2 tons, i.e., nearly the ultimate tensile strength of the wire.

Side-by-side joins

(a) Splices were made to join wires together by recognized methods, similar to that described as for (c) above, and several examples were found to approach the ultimate tensile strength of the wire. All the splices tested were considerably stronger than the anchor fastenings in which the whole wire was wrapped round the standing part.

(b) Side-by-side joins using bulldog grips were not successful, and slipping always started at a low load, sometimes as low as 0.3 tons. A further disadvantage of this type of fixing was that a spanner had to be used to tighten the nuts and there was a risk of stripping the threads while tightening. The failing load could usually be increased by tightening the nuts a little after some load had been applied, although this may not always be convenient or easy to do in the field.

CONCLUSIONS

When subjected to steady increase in load in a tensile testing machine, the most common fastenings used for attaching anchor wires to anchor rod eyes slackened and failed under loads less than half the ultimate tensile strength of the wires. Fixings made by separating the strands and wrapping them separately, or using bulldog grips in accordance with BS.462:1958, appeared to be reliable to 70-80 per cent. of the ultimate tensile strength of the wires. Wire-to-wire splices made by wrapping separated strands of each wire round the join were of comparable strength to wire-to-anchor fixings made in a similar way, but bulldog grips were unsuitable for wire-to-wire joins.

The finding that the common anchor fixings are considerably weaker than the wires themselves appears to be at variance with the experience of hop growers and of the suppliers of wirework materials, who generally consider that anchor failures initiate through breakage of anchor wires or dragging of the anchors. It follows that initial wire breakages probably take place at a point where the strength of the wire has been reduced by mechanical damage, such as notching by the strainer; further breakages may take place in undamaged wire because the initial breakage throws extra load on to the sound wires at a high rate of straining. It is not possible to do more than speculate on this point until detailed evidence has been collected from a large number of growers of the way wirework failures occur in practice.

APPENDIX I

THE CHALLENGE CUPS FOR THE NEW VARIETIES OF HOPS

F. H. BEARD

THE seventeenth annual exhibition of New Varieties of Hops was held, under the auspices of the Institute of Brewing, at 15 Southwark Street, London, S.E.1, on November 22nd and 23rd 1960. As in previous years the show was organized by Messrs. Wigan, Richardson & Co. Once again added interest was given by non-competitive exhibits staged by Mr. Derek Wigan. This year the main items were a *bale* of English hops and a collection of the many brands of lager now on the British market. It was surprising to find that over 20 British breweries are now producing lager-type beer.

Three challenge cups are competed for as follows:

(1) The Brewers' Cup; for hops intended as substitutes for American hops; this cup was presented in 1944 by Messrs. Barclay, Perkins, Messrs. Guinness, and Messrs. Whitbread.

(2) The Growers' Cup; for hops intended to augment English commercial varieties; this cup was presented in 1946 by the Association of Growers of New Varieties of Hops.

(3) The Hop Merchants' Association Cup; presented in 1949 by this Association for new varieties certified as showing tolerance to *Verticillium* wilt.

The judges were Messrs. A. J. Morris, D. G. Le May and A. E. Quin with Colonel F. N. Richardson acting as chairman of the Judges Committee.

The entry of 74 samples from 48 growers was considerably lower than the record entry of the previous year (109 samples from 70 growers) and was the lowest since 1956. The lower entry probably reflects the difficult season of 1960. Samples entered were, however, quite up to the usual standard. In spite of the wet and sunless season the alpha acids were generally only slightly lower than in the previous year, but the beta resins were generally higher by about

2 per cent. A list of entries together with the analyses carried out at Wye by Mr. J. B. Roberts, is given below in Tables 1-3.

The Brewers' Cup (Table 1) was won by Mr. W. D. Hukins with a sample of Bullion with an analysis of 8·76 per cent. alpha acids and 9·60 per cent. beta resins. Two other samples of Bullion gave slightly higher analyses. As in the two previous years no second or third placings were made in this class. There were no entries of Pride of Kent in this class, but the entries of Brewers' Gold and College Cluster were the same as in 1959.

TABLE 1
ENTRIES FOR BREWERS' CHALLENGE CUP 1960

Variety and Grower	Parish	Hops moisture free	
		alpha acids %	beta resins %
<i>Bullion (Q43)</i>			
W. H. Hoad	Hawkhurst, Kent	9·32	12·23
John Turner	Kings Pyon, Hereford	8·85	12·22
*W. Hukins	Tenterden, Kent	8·76	9·60
Dan Mackelden	Chart Sutton, Kent	8·70	10·58
Furnace Farm Ltd.	Lamberhurst, Kent	8·59	9·94
J. A. Worley	Chart Sutton, Kent	8·48	10·68
R. D. Wickham	Brenchley, Kent	7·95	10·54
E. M. Gorst	Brenchley, Kent	7·93	10·17
John Paine & Sons	East Sutton, Kent	7·47	10·43
J. Nott	Kyrewood, Worcs.	7·35	10·47
Wm. Alexander	Shoreham, Kent	7·27	10·17
Morphett Bros.	Nettlestead, Kent	7·16	10·33
Guinness Hop Farms Ltd.	Teynham, Kent	7·15	9·58
J. A. Worley	Yalding, Kent	7·12	9·55
Guinness Hop Farms Ltd.	Braces Leigh, Worcs.	7·03	9·57
J. F. Bomford Ltd.	Fladbury, Worcs.	6·95	9·95
Guinness Hop Farms Ltd.	Bodiam, Sussex	6·28	8·43
<i>Brewer's Gold (C9a)</i>			
R. D. Wickham	Brenchley, Kent	8·01	9·44
E. L. Worsfold	Sutton Valence, Kent	7·05	9·74
Guinness Hop Farms Ltd.	Teynham, Kent	6·80	8·75
Kennington Hall Farms	Wye, Kent	6·77	8·63
<i>College Cluster (N15 bis)</i>			
Guinness Hop Farms Ltd.	Teynham, Kent	4·67	6·84
Guinness Hop Farms Ltd.	Bodiam, Sussex	4·28	6·32

* Winner of Cup.

The Growers' Cup (Table 2) was won by Messrs. Courage and Barclay with a sample of Northern Brewer. This sample had the highest analysis in this class, with 9.54 per cent. alpha acids and

TABLE 2
ENTRIES FOR GROWERS' CHALLENGE CUP 1960

Variety and Grower	Parish	Hops moisture free	
		alpha acids %	beta resins %
<i>Northern Brewer</i> (WFB 135)			
*Courage & Barclay Ltd. ..	Hunton, Kent	9.54	10.60
E. B. Walker & Co. . .	Martley, Worcs.	9.53	10.03
John Dinnis & Sons . .	Shoreham, Kent	9.38	10.32
J. F. Bomford Ltd. . .	Fladbury, Worcs.	9.11	10.47
E. E. Taylor & Son . .	Kingsdown, Kent	8.95	9.87
Guinness Hop Farms Ltd . .	Teynham, Kent	8.29	9.17
J. A. Worley . .	Chart Sutton, Kent	8.19	8.95
Morphett Bros. . .	Nettlestead, Kent	8.16	9.11
Wm. Alexander . .	Eynsford, Kent	8.05	9.72
J. & P. Day Ltd. . .	West Farleigh, Kent	7.85	9.11
Wm. Skinner & Son . .	East Sutton, Kent	7.84	9.83
J. & P. Day Ltd. . .	West Farleigh, Kent	7.81	9.06
John Paine & Sons . .	East Sutton, Kent	7.66	9.14
†G. A. & S. G. Calcutt . .	Goudhurst, Kent	7.65	8.99
W. H. Hoad . .	Hawkhurst, Kent	7.65	8.23
‡S. G. & K. J. Calcutt . .	Goudhurst, Kent	7.50	8.84
James Day . .	Yalding, Kent	7.50	8.33
A. & K. J. Amos . .	Wye, Kent	7.40	8.43
G. Nott & Co. Ltd. . .	Eardiston, Worcs.	7.24	9.02
Peter B. Clarke . .	Little Chart, Kent	6.91	9.06
John Turner . .	Gold Hill, Hereford	6.51	10.13
E. L. Worsfold . .	East Sutton, Kent	6.47	8.46
<i>Pride of Kent</i> (170a)			
John Paine & Sons . .	East Sutton, Kent	6.50	12.99
J. F. Bomford Ltd. . .	Fladbury, Worcs.	6.30	12.28
E. L. Worsfold . .	East Sutton, Kent	6.26	12.27
A. & K. J. Amos . .	Wye, Kent	5.70	11.58
<i>Early Choice</i> (FF21)			
J. F. Bomford Ltd. . .	Fladbury, Worcs.	5.00	6.80
D. H. J. Britcher . .	Marden, Kent	4.03	6.37
ON78			
J. F. Bomford Ltd. . .	Fladbury, Worcs.	6.13	7.91

* Awarded Cup.

† Close Runner-up.

‡ Sample liked by Judges.

10·60 per cent. beta resins. Another sample of Northern Brewer grown by Messrs. S. G. & K. J. Calcutt was a close runner-up and the judges also liked a sample of Northern Brewer from Messrs. G. A. & S. G. Calcutt.

The Hop Merchants' Association Cup (Table 3) was won by Mr. J. A. Worley with a sample of Bramling Cross with an analysis of 5·55 per cent. alpha acids and 7·24 per cent. beta resins. Three samples of Bramling Cross and eight of Whitbread's Golding Variety had

TABLE 3
ENTRIES FOR HOP MERCHANTS' ASSOCIATION CUP 1960

Variety and Grower	Parish	Hops moisture-free	
		alpha acids %	beta resins %
<i>Whitbread's Golding Variety</i> (1147)			
Furnace Farm Ltd.	Lamberhurst, Kent	6·72	7·39
J. A. Worley	Yalding, Kent	6·27	7·22
Whitbread & Co. Ltd.	Stilstead, Kent	6·20	7·01
C. E. and W. Millson	Goudhurst, Kent	5·79	6·99
Whitbread & Co. Ltd.	Beltring, Kent	5·78	7·60
†G. A. & S. G. Calcutt	Goudhurst, Kent	5·66	6·73
Whitbread & Co. Ltd.	Beltring, Kent	5·60	7·05
J. & P. Day Ltd.	West Farleigh, Kent	5·56	7·72
J. & P. Day Ltd.	West Farleigh, Kent	5·49	7·05
James Day	Yalding, Kent	5·48	7·00
E. M. Gorst	Brenchley, Kent	5·19	7·11
D. H. J. Britcher	Marden, Kent	5·16	7·76
Courage & Barclay Ltd.	Hunton, Kent	5·13	6·02
Whitbread & Co. Ltd.	Stilstead, Kent	5·10	6·87
Whitbread & Co. Ltd.	Beltring, Kent	4·94	7·13
<i>Bramling Cross</i> (OT48)			
C. E. & W. Millson	Goudhurst, Kent	6·26	7·50
J. A. Worley	Chart Sutton, Kent	5·80	7·69
D. H. J. Britcher	Marden, Kent	5·72	7·63
*J. A. Worley	Yalding, Kent	5·55	7·24
J. & P. Day Ltd.	West Farleigh, Kent	5·20	7·22
<i>Defender</i> (D3)			
Whitbread & Co. Ltd.	Stilstead, Kent	5·78	7·67
<i>Janus</i> (J2)			
Whitbread & Co. Ltd.	Beltring, Kent	3·96	5·99

* Awarded Cup.

† Received favourable comment from Judges.

higher alpha acids content than the winning exhibit. The judges were favourably impressed by Messrs. G. A. & S. G. Calcutt's sample of Whitbread's Golding Variety.

Competition for this cup is still a contest between the above two varieties. This year there were no samples of Keyworth's Midseason entered (4 in 1959). One entry each of the newer varieties Defender (D3) and Janus (J2) demonstrated the difficulty of producing high quality samples from very small growths.

APPENDIX II

THE 1960 HOP SEASON

WEST MIDLAND REGION

G. P. CHATER
(*Hops Adviser, West Midland Region, N.A.A.S.*)

ALTHOUGH 1960 will be remembered as one of the wettest years on record, there was a period of mild, dry weather in the spring that encouraged extremely rapid growth. This growth was checked at the end of May by cold dry winds and by mid-June the wet period had commenced. In spite of the rain, lack of sunshine and rather low temperatures the crop was a heavy one of reasonably good quality. Most farms grew more than their annual quota with the result that many acres were not picked. Frequent rain during the autumn and winter caused the land to remain so wet that almost no winter ploughing or other normal winter work could be carried out.

Unfortunately, 1960 was also the year that two new outbreaks of progressive *Verticillium* wilt in Herefordshire were confirmed. Every effort to limit the spread of this disease is being made and all hop yards within a mile radius of each outbreak were inspected by officers of the M.A.F.F. Plant Health Branch. The final and most effective precautions can only be enforced by each and every individual grower. The difficulties of preventing a gradual spread of this disease are aggravated by the widespread occurrence of fluctuating wilt throughout the region.

PESTS AND DISEASES

The aphid attack was never very severe but slight infestation continued to occur until rather late in the season. Although little general damage to the hops was seen, in some cases, a late build up caused a number of yards to deteriorate more quickly than was expected.

Downy mildew basal spikes were more numerous in some yards than was expected, following the dry summer of 1959. Control measures were generally successful in spite of the very wet

period from June to September, but it must be observed that there were very few periods when any rapid spread could have been expected because of the relatively low temperatures during this period.

Some slight damage due to powdery mildew was seen in many yards but, even on Northern Brewer, control measures seemed to be effective in preventing any cases of serious damage.

Fluctuating *Verticillium* wilt caused considerable loss in many yards and was also found in many yards where it had not previously been observed. A few severe cases caused at least 5 per cent. of the plants in the infected areas to wilt before they were picked.

Nettlehead is still the disease that causes the largest loss of crop in this region. No further developments on its control have been reported recently.

Mosaic in Goldings did not appear to be any more widespread than usual.

PICKING AND DRYING

Picking operations were frequently interrupted by heavy rain and the prolonged season meant that many growths had a "tail" of rather poor hops. It was also difficult to maintain a good colour during drying when the hops had been picked in very wet periods. Hand picking is rapidly disappearing and over 75 per cent. of the growers in the region have installed picking machines which deal with 90 per cent. of the total acreage.

Two-tier driers continue to be installed and, with experience, have worked very satisfactorily. This system of drying is still comparatively new and each season provides different problems, but developments continue to be made and some growers are finding considerable advantages over the orthodox method.

An experimental baler installed in the Teme Valley produced satisfactory bales of dried hops weighing about 2 cwt. each. The present type of machine would not be suitable for small growers. Further modifications and even new ideas will no doubt eventually make the bale package easier to produce, but the extra compression may mean some alteration in drying and cooling management.

APPENDIX III

THE 1960 HOP SEASON—SOUTH EASTERN REGION

CATHERINE L. JARY, B.Sc.(Hort.)

(Hops Adviser, South Eastern Region, N.A.A.S.)

IN contrast to the heat and drought of the previous year, the outstanding feature of 1960 was the exceptionally wet and gloomy summer and autumn, culminating in extensive flooding in the Medway Valley and the Weald in October and November. The year started with good growing conditions and the hops were well advanced up to about the second week in June when the weather suggested a repetition of 1959. After that, however, there was a drastic change. July, August and early September were almost continuously wet and cool and rainfall rose to an exceptional peak in October and November when fourteen inches were recorded at Wye. Rainfall continued at much the same level during the first half of December, but there was a slight respite towards the end of the month.

The result of these conditions was a heavy crop of hops, considerably in excess of requirements in a year of 94·5% Annual Quota. The crop was harvested in very difficult conditions and the unavoidable tractor traffic in saturated gardens, followed by a winter with no frost, left the soil in very bad physical condition for the following year.

Bad as were the conditions for machine picking, they were even worse for hand picking, and in 1960 about 40% of growers in the South East were still hand picking. The transition to machines, which had been very rapid since the first three of modern design were installed in Kent in 1952, slowed down after the good summer of 1959, when pickers were plentiful and willing, but has now received a further impetus. In 1960 there were 260 machines in the South East, picking over 60% of the hop acreage there.

Contrary to experience in recent years, machines actually contributed to the quality of the final samples in 1960 (which were generally better than might have been expected in such a year) because they enabled growers to waste the excess hops and so obtain cleaner and less broken samples.

In wet years, trouble is normally expected from downy mildew, and it was certainly present throughout the season but never to the extent of being epidemic. The relatively low air temperatures no doubt kept it in check, and possibly also the rain was so continuous that spores were washed down before they could germinate. The after effects of this were seen in the following spring, especially where hops were left to blow, in the form of a bad outbreak of primary basal spike.

The worst disease of the year was *Verticillium* wilt, both the progressive and the fluctuating forms being very prevalent. The first case of the progressive form was confirmed in Hampshire and two new cases were suspected in East Kent. There was also a recurrence of one of the earlier outbreaks in North Kent. In addition to these, about fifteen new cases of progressive wilt were found on the fringe of the main infected area of Kent and Sussex, particularly in the latter county. Fluctuating wilt was particularly bad and new cases could not always be distinguished from progressive wilt by their appearance in the field. Five such cases were regarded as likely to be progressive and three as probably fluctuating, although another year's behaviour in the field will be necessary to establish which is which.

Hitherto most growers have thought of progressive *Verticillium* wilt as being present only in infected hop gardens. Even this picture is bad enough, with 320 farms and over 6,000 acres of hop land known to be infected, but because of the wide range of alternative host plants which do not necessarily show any symptoms, there must be many other concealed sources of infection. This year, in addition to the normal agencies of spread, which themselves are more effective in years with plenty of mud, the extensive floods must have distributed much infected debris from hops left unpicked in the gardens.

Consequently, no growers should regard themselves as sufficiently isolated to be safe and progressive wilt may be expected to occur almost anywhere in the South East. Nevertheless, it is frequently possible to eradicate new outbreaks with relatively little trouble, provided that the grower sees and reports suspicious hills at a very early stage before infected debris has been carried about in the garden.

Fortunately, Whitbread's Golding Variety continues to be widely accepted and of the more recent varieties, there is some hope that Janus may also prove to be. Both these varieties are being propagated extensively in East Anglia under the Ministry's

A-Plus Certification Scheme and the recently developed technique of mist propagation will enable a more rapid build-up to meet demands.

Other diseases were of secondary importance in 1960 but nettlehead continues to be a major trouble on many farms still growing Fuggle. Because of the large acreage of wilt-tolerant varieties in Kent, which up to now have remained largely free from nettlehead, this disease is becoming relatively less important there. Recent indications, however, suggest that this may be a temporary respite, since severe attacks of nettlehead have already been seen in Northern Brewer, which appeared to be field-resistant at first, and it has also been seen in Whitbread's Golding Variety.



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